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FINAL:

ENVIRONMENTAL IMPACT STATEMENT
FOR THE AIR POLLUTION VARIANCE

REQUESTED BY:

THE ANACONDA ALUMINUM COMPANY
FOR ITS ALUMINUM REDUCTION PLANT
AT COLUMBIA FALLS, MONTANA

May 20, 1974

Department of Health and Environmental Sciences
John S. Anderson, M.D., Director
Environmental Sciences Division
Benjamin F. Wake, Administrator
Air Quality Bureau
Don Holtz, Chief

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FOREWORD

This statement has been prepared by the Environmental Sciences Division of the State Department of Health and Environmental Sciences, pursuant to the Montana Environmental Policy Act, (MEPA) Section 69-6504 (b)(3).

MEPA requires preparation of an environmental impact statement whenever a state agency is considering some action that could result in a significant impact on the environment. The action contemplated in this case is a decision regarding an application for an air pollution variance by Anaconda Company for its aluminum reduction plant in Columbia Falls, Montana.

This department, with the help of other agencies and members of the public, must advise the Board of Health and Environmental Sciences whether granting the variance would result in the continuation of emissions into the air to an extent sufficient to constitute danger to the public health and safety, and whether denial of the variance would produce hardship without equal or greater benefits to the public.

Comments or questions regarding the impact statement or the proposed variance should be directed to Daniel Vichorek, Technical Writer, Environmental Sciences Division, Cogswell Building, Helena, Montana, 59601. There will be no decision on whether the variance should be granted for at least 30 days following issuance of this statement.

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I. INTRODUCTION

A. Summary

The Anaconda Aluminum Company Division of The Anaconda Company has petitioned for variance from compliance with certain air pollution control requirements of the Department of Health and Environmental Sciences pertaining to fluoride emissions, particulate emissions and visible emissions.

The company has proposed certain actions in lieu of compliance. The Anaconda Aluminum Company (AAC) has provided no assurance of compliance, at any time.

Present emissions continue to damage vegetation and subject people and animals to the risk of adverse effects. The need for emission control and compliance has been clearly demonstrated.

Control technology sufficient to comply with the regulations exists and is in use today. The cost of such control is commensurate with other plants' pollution control expenditures.

The department therefore will recommend to the Board of Health and Environmental Sciences that the variance request be denied.

B. The Petition

AAC has petitioned the State Board of Health and Environmental Sciences for exemptions from certain air pollution regulations set by the board. The petition seeks a one year variance to allow development of a new process for abating certain emissions from the company's Columbia Falls plant. The applicable regulations are 16-2.14(1)-S1430, -S1460 and -S14080 of the Montana Administrative Code (MAC). The regulations pertain to particulate emissions, visibile emissions and fluoride emissions. Copies of the regulations are included in Appendix A as is a copy of the variance petition.

Emissions of fluoride from the plant violate regulation S14080 Aluminum Plants, Fluoride Emissions, effective June 30, 1973. Particulate emissions also may be in excess of the applicable standards.

AAC has installed some air pollution control equipment to collect and treat emissions from the process, but large quantities of fluorides and particulate matter escape this system and are emitted from the roofs of the buildings enclosing the process equipment. There is no pollution control equipment to treat the roof emissions from the plant.

According to the variance request, "...there seems to be only three additional air pollution control strategies which could reduce the current level of the plant's emissions." They are a conversion of the plant to a different process, installation of roof scrubbers of the type now employed elsewhere in the industry, and development of a new type scrubber.

Anaconda Aluminum proposes that a variance be granted for one year to allow further study of some new type of scrubbing system. The petition contains no provisions for, or predicitions of, compliance with the existing regulations. The company reserves discretion as to the technical and economic suitability of the device being studies. Given the information in the petition, ten percent of the roof emissions might be treated by July of 1976 but beyond this point, a timetable for control is nonexistent and control methods are at best indefinite.

C. Variances

Variances are allowed by Section 69-3916 Revised Codes of Montana (RCM, 1947), which is summarized below.

Any person responsible for emissions subject to regulation may apply for an exemption or partial exemption from such regulations.

The Board of Health may grant the variance "if it finds that:

a) The emissions occurring or proposed to occur do not constitute a danger to public health or safety; and

b) Compliance with the rules or regulations from which exemption if sought would produce hardship without equal or greater benefits to the public."

No variances may be granted without a public hearing and without consideration of the interests of all parties concerned or affected.

No variance shall be granted for more than one (1) year although an exemption may be renewed for like periods.

Further, a variance is not the right of an applicant but is in the discretion of the board, and shall not prevent or limit the application of the emergency provisions of the Montana Clean Air Act.

D. MEPA

The Montana Environmental Policy Act of 1971 (MEPA) requires that a detailed statement of environmental impacts be prepared on major action of state government "significantly affecting the quality of the human environment." In the case at hand, the action by the Board of Health in regard to the variance petition will constitute such an action of state government and require an environmental impact statement (EIS).

II. DESCRIPTION OF PLANT AND PROCESS

A. Basic Manufacturing Process

Primary aluminum manufacture employs the Hall-Heroult electrolytic reduction process. Alumina ore is dissolved in a molten bath of cryolite contained in a steel crucible with a carbon lining (cathode). An electric current is then passed from a carbon block (anode) suspended above the bath through this bath to the cathode. The current reduces the alumina ore (AL_2O_3) to molten aluminum metal and oxygen, and the molten aluminum is withdrawn from the cell into large crucibles and cast in the desired forms.

The raw materials for the process are coke, pitch, cryolite, aluminum fluoride, alumina ore, and electric energy. The alumina ore is a refined form of bauxite, a naturally occurring ore of hydrous aluminum oxides and hydroxides, the major sources of which are in South America and Australia. Anaconda Aluminum's ore is shipped from Jamaica to Columbia Falls via ship and rail. Cryolite, a double fluoride salt of sodium and aluminum ($3NaF \cdot AlF_3$ or Na_3AlF_6), is used for the cell electrolyte and as a solvent for alumina. Table 1 gives the composition of Anaconda Aluminum's cryolite. Alumina ore is the prime source of aluminum for the process, although the cryolite and aluminum fluoride provide some. An analysis of the alumina is given in Table 2. Aluminum fluoride is consumed in the cells and is added to maintain optimum operating conditions in the pot. See Table 3. Metallurgical and petroleum cokes are purchased and processed into anodes and cathode paste. See Table 4.

Anaconda Aluminum employs electrolytic reduction cells, or pots, of the vertical-stud Soderberg design. A schematic diagram of the vertical-stud pot is shown in Figure 1. The cell itself is about 27 feet long, 14 feet wide and has a total height of approximately 15 feet. The bottom of the cell is a steel tub lined with the carbon cathodes. The top of the cathode is about at floor level; therefore, the bottom of the anode is approximately at floor level and the

Table 1

CRYOLITE ANALYSIS (1)

Molecular Composition	Range (%)
Silicon (Elemental)	0.2-0.35
Fe_2O_3	0.02-0.1
Cryolite (Na_3AlF_6)	90-95
CaF_2	0.04-0.06
Al_2O_3	3-5
H_2O	0.05-0.15
Elemental Composition	
Fluorine (F)	48-52
Sodium (Na)	31-34
Aluminum (Al)	13-14

Table 2

ALUMINA ANALYSIS (1)

Molecular Composition	(%)
SiO_2	0.01
Na_2O	0.58
TiO_2	0.002
Fe_2O_3	0.014
H_2O	0.245
Loss on ignition	0.485
Al_2O_3 (Diff)	98.665

Table 3

ALUMINUM FLUORIDE ANALYSIS (2)

SiO_2	0.16
Fe_2O_3	0.015
AlF_3	94.5

Table 4

COKE ANALYSES (3)

	Petroleum	Metallurgical
Ash	0.39	6.84
Si	0.03	--
Fe	0.04	--
S	1.03	0.63
H_2O	0.03	13.1
Volatile	0.34	0.73
Fixed Carbon	--	92.45

VSS SODERBERG CELL
SCHEMATIC ARRANGEMENT

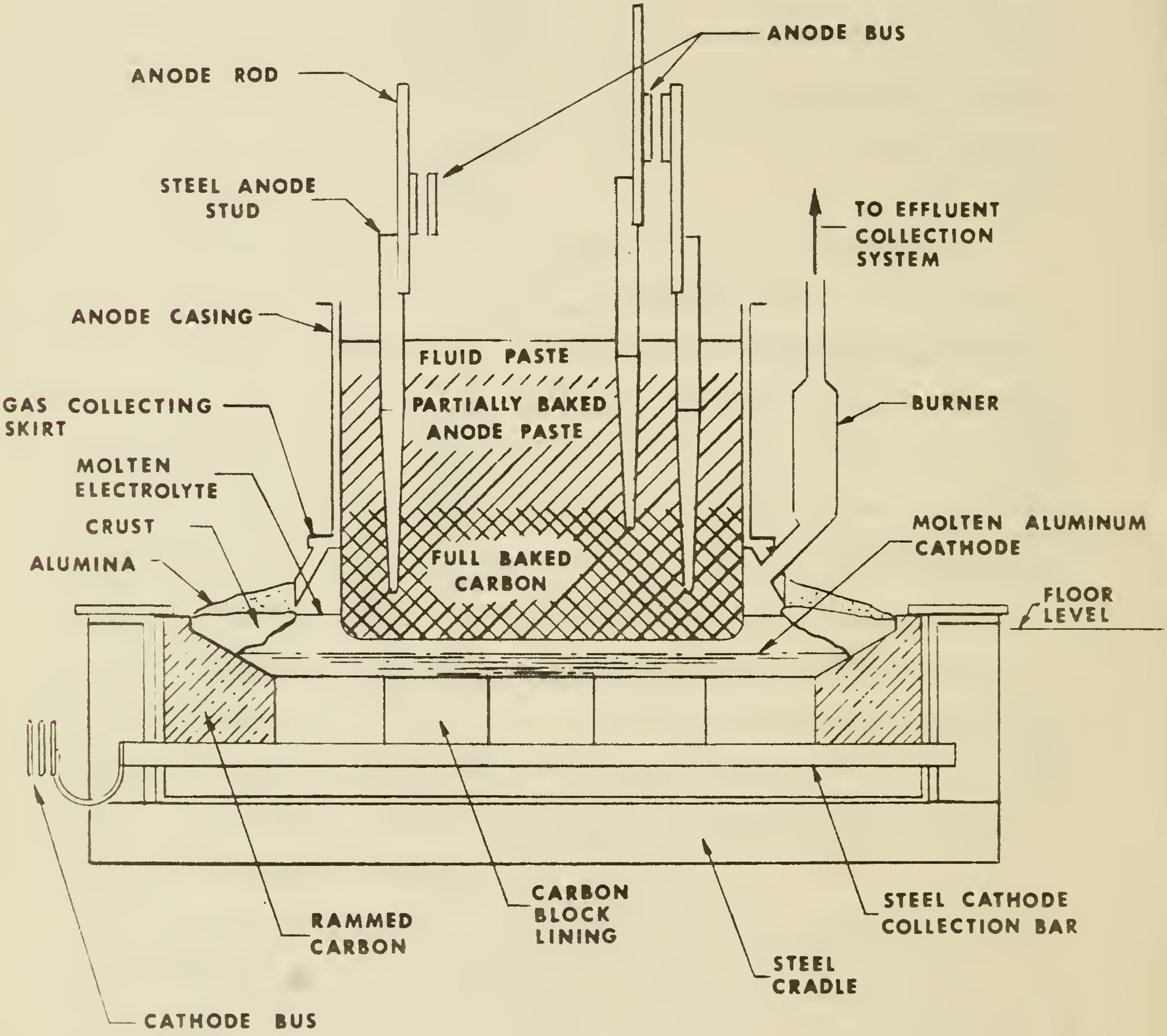

FIGURE 1

pot is suspended from the floor. The anode is a mixture of fresh anode paste, partially baked paste, and solid carbon suspended from vertical steel pins, or studs. The anode is surrounded by a steel casing with a gas collection skirt at the bottom for collection of the pot gases. As can be seen in Figure 1, the skirt extends out over the molten cryolite to the frozen crust of cryolite and alumina.

The cathodes are composed of carbon blocks laid into the steel pot bottom, and "mortared" in place with cathode ramming paste. Anaconda Aluminum purchases the blocks and makes its own cathode ramming paste and anode paste in the paste plant. The "baked-in-place" anodes used in Soderberg cells are formed by grinding petroleum coke and mixing it with pitch, which is formed into anode paste briquettes, and transported to the potlines and eventually placed on top of the anodes.

Electrical power is supplied to the anodes by bus bars connected to the studs (see Figure 1). A collector bar in the pot bottom provides the complete electrical circuit.

The current supplied generates large quantities of heat which drives the volatile hydrocarbons out of the briquette, forming a solid block of carbon, baked onto the steel pins. The heat also serves to maintain a molten bath in the cell.

Current passes from the anode to the cathode and electrolytically reduces the Al_2O_3 to aluminum and oxygen. The cell reactions are:

Bath: $Al_2O_3 \longrightarrow 2Al^{+++} + 3\ O^{--}$

Cathode: $Al^{+++} + 3\ e^- \longrightarrow Al$

Anode: $O^{--} \longrightarrow O + 2e^-$

The molten aluminum (2.3 gms/cc) is denser than the molten electrolyte (2.1 gms/cc) and sinks to the bottom of the pot. The anode is consumed as the oxygen combines with some of the carbon from the anode to form carbon monoxide and carbon dioxide.

Some hydrocarbon remains in the anode, is vaporized and is partially burned. Referring to Figure 1, one can see the basic configuration of an operating pot showing layers of aluminum, bath and crust. The cryolite, alumina, and aluminum fluoride are introduced by spreading them on top of the frozen crust around the cell. Periodically, the crust is broken and the raw materials are forced into the bath. This causes dusting of the ores and allows pot gases to escape. The molten bath contains various chemical forms of the raw materials.

The degree of efficiency in aluminum production is a function of several factors, many of which are limited by design. Variables in the process are largely restricted to such operation conditions as current density, current flow, bath temperature, bath ratio, and bath composition.

Cell current density at the Columbia Falls plant averages 4.89 ampers/ square inch (A/in^2), at a total cell amperage of 107,500. Voltage drops are 798.16 millivolts (mV) across the anode and 445.66 mV across the cathode. Cell voltage averages 5.383 V. With the plant's 1972 production rates, total energy consumed was 3.2 billion KWH or an average of 8.49 DC kilowatt-hours per pound of aluminum (DC KWH/LB) with ranges from 8.675 DC KWH/LB to 8.373 DC KWH/LB (1). One recent plant with a different cell type was designed to operate at 6.5 KWH/LB (4).

Anaconda Aluminum operates its pots at a bath temperature averaging 966°C with a range from 955 to 974°C. Elsewhere in the industry cells are operated from 940 to 980°C (5). Another source (6) states that normal cell operating temperature is about 975°C. Commercial bath ratios (wt. ratio of NaF to AlF_3) range from 1.10 to 1.40 (5). The pots at Columbia Falls average a bath ratio of 1.23. Bath composition--the relative amounts of the raw materials and their related compounds--is quite variable and difficult to assess. Alumina concentration, which has a decided effect on fluoride emissions, is kept within the solubility range of the electrolyte. (2-6 weight %).

Ancillary operations to the potlines are the paste plant previously mentioned, the casting area, and fabricating plant.

The Columbia Falls plant consists of 600 pots with a total rated capacity of 180,000 tons per year (TPY) of aluminum metal or about 500 tons per day (TPD). The plant has 10 buildings or potrooms, each containing 2 rows of 30 pots. Two buildings comprise a potline (120 pots).

The major raw materials used are listed in Table 5 and quantities used in 1971 are given (AAC data).

B. Sources and Nature of Pollution

GENERAL

Anaconda Aluminum has requested a variance from the regulations pertaining to particulate matter and fluorides as applied to the reduction plant. The total impact of the plant is the cumulative result of all the emissions, including sources for which no variance is requested. Prime pollutants from aluminum reduction plants are gaseous and particulate fluorides, aliphatic and aromatic hydrocarbons as particulate, and raw material particulate. Discussion of the environmental effects of the various pollutants is contained in Section IV.

The AAC paste plant processes cokes and coal tar pitch to anode paste and cathode paste. Emissions are generated at several points in the plant. Coke dust, primarily carbon, from the unloading and transfer facilities is collected in cyclones and baghouses. Emissions from the metallurgical coke dryer are scrubbed in a venturi scrubber installed in 1972. Pitch is used as a binder for coke to form the anode paste and cathode ramming paste. The carbon cathodes are formed by baking a metallurgical coke-pitch mixture in molds to drive off the pitch leaving a monolithic carbon block about 2 feet on a side. This process is not performed at Columbia Falls because AAC purchases its cathodes. The company, however, makes the cathode ramming or green paste used for assuring good electrical contact between cathode blocks, and for filling voids not suitable to

Table 5

Materials Used at Anaconda Aluminum Company (7)

Basis - 180368.4 tons/year Al Metal

Inputs	Tons/Year	#/Ton Al
Alumina	392,886.0	4356
AlF_3	11,536.2	128.2
Cryolite	3,766.8	41.8
Anode Paste	108,273.6	1200
Cathode Paste	1,489.6	16.5
Carbon Blocks	1,138.8	12.6
Sidewall Blocks	438.0	4.9
Borax	87.6	0.97
Iron	175.2	1.94
Ferro Manganese	262.8	2.91
Silicon	8.8	0.098
Lime	8,497.2	94.2
	528,605.1 TPY	
Electricity	3.06×10^9 KWH	16,965 KWH/Ton Al
Outputs		
Aluminum	180,368.4	2000

the flat-sided carbon blocks. With the exception of the metallurgical coke dryer, emission sources in the paste plant are controlled to an extent with baghouses. Carbonaceous dusts continue to be emitted.

Cell emissions consist of numerous chemical forms and considerable research has been done to identify them. The pollutants found within the cell itself are primarily hydrogen fluoride (HF) gas and particulate matter consisting of cryolite, chiolite, and aluminum fluoride. According to AAC, gaseous fluorides, principally HF, constitute 90% of total F emissions. The other 10% is in particulate forms as 60% cryolite ($Na_3 \cdot AlF_6$) 20% chiolite ($Na_5\ Al_3\ F_{14}$) and 20% aluminum fluoride (AlF3). The literature reveals that pot gases may contain such particulates as carbon, sodium fluoride (NaF), calcium fluoride (CaF_2) alumina, and various complexes of sodium, aluminum, calcium and fluorine. Gaseous emissions may include carbon tetrafluoride (CF_4), silicon tetrafluoride (SiF_4), carbon disulfide (CS_2), carbonyl sulfide (COS), hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). The pot gases also contain large volumes of carbon monoxide and carbon dioxide from oxidation (combustion) of the sacrificial anode and some tarry hydrocarbons from the anode.

The anode top is another significant source of emissions. The coal tar pitch used as anode binder contains significant quantities of aromatic hydrocarbons. As the heat from the reduction process bakes the anode in place, these aromatic hydrocarbons, along with other volatiles, are driven off into the potroom atmosphere. This process is very similar to coal carbonization and to coke manufacturing in a coke oven, in that coal tar volatiles are driven off leaving primarily carbon. Coal tar pitch has been implicated as a significant source of carcinogenic (cancer producing) organic compounds (8, 9, 10).

FLUORIDES

Large quantities of fluorides are emitted from the cells which is not surprising considering that the fluoride input to the cells is about 110 pounds of F per ton of aluminum produced. (AAC data for 1971). Not all the F, however, is emitted. Up to 40% may be absorbed by the carbon lining of the cathode and there are other minor losses. THese figures may vary from time to fime. Fluorine, the most electronegative of all elements, is extremely reactive, and is not found in its elemental state in pot gases or elsewhere in nature.

The factors which affect the efficiency of aluminum reduction are electrolyte conductivity, bath temperature, cryolite or bath ratio, alumina concentration, bath composition, electrode spacing, and current flux. Several of these have considerable effect on fluoride emissions, including bath temperatures, bath ratio, alumina concentration and current flux.

The amount of current supplied to a cell directly affects the production rate of aluminum. Oversimplified, the more current that is supplied, the more aluminum is produced. Correspondingly, as aluminum production rates are increased, fluoride evolution is increased. Design of the cell and electrical system limit the amount of current which may be supplied to the cell, to a minimum and maximum. The alumina concentration affects fluoride evolution inversely; that is, an increase in alumina concentration decreases fluoride emission (11, 12).

Bath ratio, the weight ratio of NaF to AlF_3, also affects fluoride emissions inversely. Therefore, a decrease in NaF or increase in AlF_3 will decrease the bath ratio and increase fluoride emissions.

Fluoride emissions vary directly as bath temperature. As bath temperature increases, fluoride emissions increase. THis is largely due to the increase in vapor pressure of HF.

The predominant gaseous fluoride emitted is HF which combines with water vapor to form aqueous hydrofluoric acid. Fluorides emitted as particulate can be found as gases in the pot atmoshpere. Condensation and equilibrium shifts of the melt species result in this phase change. The relative quantities and nature of fluoride emissions are affected by the previous parameters according to a variety of complex chemical and physical mechanisms, many of them ill-defined.

Referring to the data on page 8 describing the operating parameters of the Columbia Falls plant, one can see that the plant is in "the middle of the road." It is operated neither at maximum production rates, nor at minimum pollution rates. It should also be mentioned that operational changes resulting in increased production result in a higher relative rate of emission, e.g., a 10% production increase could conceivably increase fluoride emissions by 20%. Conversely a 10% production decrease could conceivably reduce F emissions by 20%. The percentages are illustrative only and not intended to represent actual occurrences.

As all effluents generated are not emitted to the atmoshpere at the same point, they are categorized as either primary or secondary depending on the emission point. Those emissions collected by the pot gas collection system and treated in the primary system are the primary emissions and, prior to treatment, constitute the bulk of the total pollutants generated. Those pollutants escaping the collection system through the crust and the hydrocarbons from the anode top, whether treated or not, are referred to as secondary emissions.

HYDROCARBONS

Hydrocarbon emissions are both primary and secondary. In the pot itself, a certain amount of organic material is present in the anode which is liberated as the anode is consumed. Special burners on the pot serve as after-burners for the pot gases to combust most organic material to CO_2, CO and H_2O prior to introduction to the primary treatment system. Similar hydrocarbons are driven off the anode top as previously described. This results in the blue haze seen near aluminum plants.

PARTICULATE

In addition to the hydrocarbon particulates described above, large quantities of other particulate matter are emitted from the cells including some particulate fluoride. Dusting of the raw material during pot working is one major source. Other sources are solids from volatilized bath and entrainment of crust material in air. According to AAC, about 10% of total fluoride emissions are in particulate form and the particulate contains about 15-20% fluorine. It has been reported (13) that alumina losses via air emission average 3 lbs per ton of aluminum produced (TAP). Mechanical and electrochemical dusting of the anodes also contribute to particulate emissions.

C. History of Plant and Existing Controls

The Anaconda Aluminum plant at Columbia Falls was built in 1955. At that time the plant consisted of two potlines with a total of 240 pots. The pollution control devices for air emissions were multiclones and low efficiency wet scrubbing systems. The original system used the multiclones as particulate collection devices, and the scrubbers were used almost exclusively as gas scrubbing devices. In 1965, one additional potline was added to the plant bringing the total number of cells to 360. This line was equipped with the same pollution control system as on the existing lines. In May, 1967, the state Board of Health adopted, after lengthy hearings, ambient air quality standards which included fluoride standards. In 1968, two more lines (240 pots) were added. It was estimated that emissions from the total plant were approximately 7500 lbs/day (15 lbs/TAP) of gaseous and particulate fluorides. The company made no estimates of 1968 emissions of particulate.

By the summer of 1970 the company reported fluoride emission reductions from 7500 to 5000 lbs/day (15 to 10 lbs/TAP) and obtained some reduction in the amount of particulate matter through changes in the system operating parameters. In May, 1970, the State Board of Health and Environmental Sciences promulgated a regulation restricting emissions of fluorides from aluminum plants, with an effective date of June 30, 1973, for existing plants.

Anaconda Aluminum had been studying various control systems and a program was instituted to replace the existing scrubbers with venturi type scrubbers and packed towers. It was early 1972 before the full effect of the improvements and modifications to the control system were obtained and the company reported total fluoride emissions from the plant of 2500 lbs/day (5 lbs/TAP) and particulate emissions of 6500 - 8500 lbs/day.

After the issuance of the draft environmental impact statement on February 7, 1974, AAC submitted some data on their fluoride emissions from the last half of 1973 (14). The average for the period was 1448 lbs/day. During this period, however, production was curtailed from 500 TPD to about 380 TPD. Equivalent emissions were 3.7 lbs F/TAP.

The fluoride regulation allows a fluoride emission of 864 lbs/day (at full production) or 1.73 lbs F/TAP. The recent AAC data indicates a primary system emission of about 0.58 lbs/F/TAP and a secondary emission of about 3.13 lbs F/TAP. These figures result in a full production daily emission equivalent to 290 and 1515 lbs, or a total fluoride emission of about 1855 lbs. of fluoride per day.

To date, the extent of the particulate emissions remain somewhat in doubt. The figures mentioned previously are based on operating experience and testing from several other plants. The present system of control at Anaconda Aluminum is primary collection only. There is no air pollution control equipment for cell emissions not collected in the primary system.

D. Company's Variance Proposal

AAC's petition perceives that compliance with Montana's regulations would necessitate the installation of collection devices for the emissions from the potroom roofs. Regulation S14080 allows fluoride emissions of 0.060 lbs/hr/pot. For AAC at full production, this permits emissions of 36 lbs/hr or 864 lbs/day corresponding to about 1.73 pounds of fluoride per ton of aluminum. Best available data on particulate emissions from the plant based on both AAC and state testing, indicate primary system emissions of 1,000 lbs/day (2.0 lbs/ton) and secondary emissions of from 6,000 to 8,000 lbs/day (12-16 lbs/ton). Montana's existing particulate regulation as of the date of AAC's variance petition was subject to interpretation, the most reasonable form of which would have allowed AAC to emit 9.4 lbs of particulate/TAP or 4700 lbs/day. The department has proposed a clarification of the particulate standard which is consistent with the fluoride standard in terms of technical feasibility, level of control and cost. Further discussion may be found in Section IIIC. The standard would permit particulate emission of 0.33 lbs/hr/pot or approximately 9.4 lbs/ton of aluminum.

AAC's primary system is relatively efficient, although some other plants have better systems. Some improvements might be made to the AAC system but even zero emissions from the primary system would not bring the plant into compliance.

AAC has proposed to study the use of foam scrubbers on the roof emissions. AAC recently purchased and is experimenting with one very small pilot plant scrubber to give the company some operating data regarding the performance and the cost of such a device. The device being researched is not familar to the industry or the state. It is called the "Foamator" and was developed by Temperator A.B. of the Alfa-Laval group, Stockholm, Sweden. Presently, Foamators are available to handle gas flows up to 150,000 cubic meter/hr but have never been used on U.S. aluminum plant effluents. Recent reports indicate, however, that a similar device may have been used at a Russian aluminum plant.

Conventional roof emission treatment requires large volumes of water in the system. Present practice elsewhere is to use water once and discharge it to a river, bay or ocean. At Columbia Falls such a discharge would not be permissible so wastewater treatment would be required. The most important advantages of the foam scrubber would be its low volume of liquid discharge requiring treatment. Preliminary estimates indicate the conventional system would require treatment of 25,000 GPM of water compared to less than 1000 GPM for the Foamator.

AAC is engaged in research and development (R & D) on the foamator's applicability to the aluminum smelter. The proposal for this work is contained in the variance petition. AAC presently has a unit whith a 5' x 5' foam bed installed on one roof. A 10' x 10' unit has undergone lab testing in Sweden to establish that a foam bed that size could be generated. Testing at Columbia Falls has attempted to establish the best foaming agent and to determine system efficiency and certain other operating variables.

AAC reports that it entered into an agreement with Alcoa and Alfa-Laval for development of the Foamator, and will not divulge some relevant information. Such information includes the nature of the foaming agent, the manner in which the foam bed is generated and controlled and the type of effluent treatment under consideration. At this time neither the results of the testing nor any other information necessary to evaluate the device have been provided. However, at a Board of Health hearing on March 18, 1974 on amending the regulations, AAC claimed that the Foamator was achieving 85% removal of fluoride and 75% collection of particulate matter, and offered to let the state test that unit in cooperation with AAC. No test data have been supplied to date, however. AAC did supply the board, on March 18 with a possible configuration for applying Foamators to their rooflines. Further testing is scheduled to determine scale up factors, cost data, optimum module size, auxiliary equipment requirements and long-term performance.

AAC will install enough units to treat emissions from 60 feet of roofline for one year of testing. Startup is scheduled for July 1, 1974. AAC proposes that, thereafter, if testing indicates economic and performance feasibility, additional units may be installed on one roofline for 10% of the total roof emissions. One additional year of testing is proposed for this installation.

Even if the Foamator were to prove a complete success, AAC gives no assurance tha the entire plant would be controlled, nor is any time schedule proposed for additional installations. Moreover, they have made no provisions for alternate strategies or compliance attempts.

III. CONTROL METHODS & COMPLIANCE

A. Technical Feasibility of Controls

A number of different techniques have been employed by the operators of aluminum smelters to control the emissions of air pollutants. Conventionally, two different techniques or devices have been employed to control emissions - one method for gaseous pollutants and one for particulate. This is logical as removal of the two classes of pollutants generally entails different chemical and/or physical processes. While some methods achieve both gaseous & particulate control, a given method is usually significantly better at removing one or the other of the classes.

In the following, control methods will be discussed in terms of primary and secondary control, despite some overlap. AAC says such a configuration is necessary and has addressed the problem in that manner. Further, the aluminum industry conventionally has installed two separate systems.

There are several types of efficiency figures used in discussing the control of pollutants in aluminum plant emission. The pot gas collection system attempts to convey the reduction cell off-gases to a primary control system in a relatively concentrated form. Some gases and pollutants escape this system. Skirt efficiency, pot gas collection efficiency, and hooding efficiency describe how much of the pot emissions are conveyed to the primary system for treatment, expressed as percentages of total pot gas. Treatment, collection, removal or system efficiency is a percentage measure of how much of the pollutant entering a device is removed by the device. The pollutants in the pot gases are far more concentrated than those escaping into the potroom and hence are easier to treat. Also the air volumes are far less, thereby lowering the size and cost of the required treatment device. Gases escaping this system are diluted in the potroom and systems to treat these emissions must be large enough to handle large air volumes. These systems are less efficient because of the dilute concentrations.

PRIMARY CONTROL

Primary control at Columbia Falls is achieved with multiclones, venturi scrubbers, and packed towers. The multiclone is an inertial separation device used for preliminary particulate removal prior to the wet collectors. Contaminated air is introduced tangentially to several banks of cylindrical tubes with conical bottoms. Larger particles are forced to the outside of the cyclonic gas flow and removed from hoppers in the bottom. Partially cleaned air then passes up through the tubes into a duct to the venturi scrubber. Venturi scrubbers are high-energy, high pressure drop collectors. Gases are forced through a rectangular tube with a constriction or "venturi." Water is sprayed into the venturi throat where it is atomized by the rapidly moving gas stream. Residence times are short, but the extreme turbulence promotes good solid-liquid contact. Particulates contact water droplets, thus increasing their size and ease of removal. The packed tower is a large diameter cylinder filled with material designed to provide large surface area in minimum volume. Gas velocities through the tower are low to provide time for gaseous components of the air stream to react with the liquid in the tower. Anaconda Aluminum has claimed a hooding efficiency of better than 90%, which is quite high compared to other VSS systems, reported normally at 85% efficiency.

Multiclones (MC) can achieve removal efficiencies of at least 90% for particles in the 5-10 micron (u)* range and higher for larger particles, lower for smaller ones. Expected efficiencies on pot gas fumes with an installation like that at AAC is about 45%. Venturi scrubbers (VS) are primarily particulate collection devices but some gaseous pollutant removal is obtained. In combination with the packed tower, the venturi should achieve almost 90% control efficiency of particulates and 99% on gaseous fluorides. Testing of AAC's combined multiclones, venturi scrubbers and packed towers indicates that overall efficiencies for the system are 98.3% on total fluorides and 93.7% on particulate matter. This system as operated now, has total fluoride emissions of 0.58 lbs F/ton Al or 290 lbs/day and particulate emissions of about 2.0 lbs/ton Al or 1000 lbs/day.

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*1 micron = .000001 meter = 1/25,400 in.

There is a variety of different systems in use at other plants around the world, with varying degrees of success. Some systems have not been applied to VSS pots like those at AAC. Those mentioned here are in use or could be used on vertical stud pots. It should also be mentioned that efficiency figures and lbs/ton emission figures are not necessarily applicable to AAC's plant because of differences in pollutant concentration and nature of emissions. They do provide an indication of what is being done elsewhere. Pot design and layout, raw material variations, water supplies and treatment, and plant operation affect the emission data.

The Martin-Marietta (formerly Harvey Aluminum) plant at the Dalles, Oregon was built from essentially the same Pechiney plans with some minor modifications, as AAC's Columbia Falls plant. Martin-Marietta's system which originally consisted of wooden scrubber towers, has been substantially improved three times in the last ten years and now employs a primary system of bubbler chambers followed by wet electrostatic precipitators (WESP). The bubbler chambers or bubbler scrubber (BS) are simply large concrete chambers with drains into which water is sprayed for HF removal. The wet gases are then conducted to wet electrostatic precipitator (ESP). Particles are given an electric charge and passed by oppositely charged electrodes. The particles are attracted to the electrodes where they collect. Periodically, the electrodes are rapped mechanically to dislodge the collected material, which then falls into hoppers for removal. A wet ESP collects wet particles and requires different design than a dry ESP (DESP). Usually no product recovery is obtained from wet ESP's. Martin-Marietta's WESP system achieves "efficiencies of up to 99.66% on total fluorides and 99% on particulate" (15). However, wide variations in system efficiencies have been reported. Assuming similar normal efficiencies, the Martin-Marietta system, if applied to the Columbia Falls plant, would result in emissions of 0.16 lbs F/ton Al or 80 lbs/day of total fluoride (a reduction of 72% from current) and 0.32 lbs/ton Al or 160 lbs/day of particulate (a reduction of 84% from current). Table 6a presents comparisons of AAC's emissions and what might be emitted if a different system were employed.

A relatively recent innovation in the treatment of aluminum plant effluents is the "dry scrubber." There are three varieties of this system--the fluidized bed (FBDS), coated filter (CFDS), and injected alumina (IADS). All three systems take advantage of the tendency of alumina to adsorb HF. After the HF has been scrubbed out, baghouses remove particulate matter from the gas stream.

The Alcoa 398 process, the fluid bed system, passes the pot gases through a reactor containing a fluidized bed of alumina, which adsorbs gaseous HF. A baghouse is employed downstream to filter any entrained particulate matter. In the coated filter system, either Alcoa 173 or Wheelabrator, the bag filters are coated with a layer of alumina from a source extraneous to the gas streams. Pot gases are passed through the filters where gaseous HF is adsorbed by the alumina and particles are filtered out by the alumina layer and fabric filter. This system is being replaced by other dry scrubbing systems in several installations (13).

In the injected alumina system developed by Alcan, ore grade alumina is injected into the gas stream. The system is designed to provide sufficient time for HF adsorption before the dust in intercepted by a baghouse. The recovered alumina is then fed to the pots without further treatment. These systems have one very beneficial consequence. As HF is adsorbed, it reacts with the alumina. The overall reaction is: $Al_2O_3 + 6HF \longrightarrow 2AlF_3 + 3H_2O$. The final result is AlF_3, one of the process raw materials. The collected material from these systems may be reintroduced to the pots without further treatment. As an aside, the product recovered often is valuable enough to more than pay the operating cost of the system, which thus becomes profitable.

The Alcoa 398 process is at least 99% and frequently over 99.9% efficient on gaseous fluorides. The associated baghouses usually trap 98% of the particulate (16). Overall fluoride efficiencies are 98.6% on prebaked potlines (U.S. installation) and 98.9% on VS lines (foreign) (13). Design of the coated filter system is 99% on particulate (and particulate fluoride) and 98% on gaseous fluorides. Actual operation efficiencies of 98.2% on gaseous F and 99.3% on particulate have been achieved (17). The injected alumina system has a 98% efficiency on all pollutants, as applied to U.S. prebake lines and foreign vertical stud lines (13).

A variation of the Martin-Marietta (MM) system has the precipitator ahead of the scrubber or gas removal device. Such a system is employed by Montecatini Edison at several of its plants in Italy. Placement of the dry ESP first in the system is more advantageous than the MM system because it allows the recovery of dry products which can be reused, and because it eliminates the solids buildup in the scrubber waters. Also, materials handling is simpler than with a wet ESP. In the variation there are two consecutive scrubbers which use a 2.5% NaOH caustic solution. The scrubbers are merely spray towers (ST) in which the gas stream passes upward and water is sprayed down. Scrubbing water is treated for fluoride recovery. Precipitator efficiencies of 96-97% and overall system efficiencies of 99% on solids and 99.6% on fluorine are claimed (18).

Another system in use is very similar to Martin-Marietta's, except that the bubblers are replaced with packaged wet scrubbers. The wet scrubbers can be any of several designs with the primary purpose of controlling gaseous fluoride emissions. The types used are spray towers, venturis, and packed scrubbers. Gaseous removal efficiencies of 98-99% are not uncommon (19). The wet precipitators are similar to those previously described.

SAKO's Sundsvall aluminum works in Sweden uses a floating bed of plastic balls in the primary system scrubber. The packed bed (PB) scrubber is a cylindrical tower containing about 15,000 1½" plastic balls. The balls are retained by plastic nets and water is sprayed upwards from below concurrent with the gas stream. The plastic balls serve a purpose very similar to the packing in a packed tower, except the upward movement of gas and water causes violent action by the balls. The operating efficiencies of this system are 78% for solids and 97.5% of gaseous fluorides (20). Refer to Table 6a for a comparison with Anaconda Aluminum.

Another available system consists of a venturi scrubber used by itself for both fluoride and particulate control. Such systems have been designed with efficiencies of 96% on solids and 99% on HF (19). However, such efficiencies have high energy requirements, and similary efficiencies can frequently be achieved with other systems at lesser costs.

SECONDARY CONTROL

Aluminum reduction cells generate and lose tremendous quantities of heat. To maintain a suitable working environment for plant personnel, both fluoride and hydrocarbon concentrations and temperatures must be reduced. Large volumes of outside air are admitted to the building for dilution, thereby lowering the potroom temperature and pollutant concentrations.

Various aluminum plants have installed secondary air pollution control systems. Both ground and roof support units are used and all use water, treated or untreated, as a scrubbing medium.

The spray chamber (SC) system used by Martin-Marietta, is a combination of roof units and tunnels utilizing a number of roof-mounted fans to draw the potroom air through a series of water sprays. Fresh water is used in the sprays, and the water collected in troughs below the sprays is discharged to the river. Efficiencies are reported as 88% on gaseous F, 42% on particulate F and 77% on total particulate (15). Table 6b presents comparisons of possible treatment methods with existing emissions levels at Columbia Falls.

A VSS plant on Nogueres, France, owned by Pechiney, is equipped with tubular atomizers. These are horizontal tubular scrubbers mounted in the roof ventilators. Potroom gases are drawn into one end of the scrubber and sprayed with a caustic solution. The effluent is treated for fluorine recovery and recycled. A similar device is used at Intalco, a prebake plant in Ferndale, Washington, partly owned by Pechiney. Fluoride removal of 80 to 85% in the roof scrubbers is achieved (21). Refer to Table 6b for emissions comparison. These emission comparisons are meaningful in that both AAC's Columbia Falls plant and MM's plant at The Dalles were built originally from the same Pechiney plans. Even at that time (1955), Pechiney was employing better pollution control systems than were installed in the U.S. plants. Table 6c compares the total lbs/ton emissions from the Intalco plant to AAC's lbs/ton emission. Total emissions are not presented because of the difference in plant size.

The spray tower (ST) is very similar to the spray chamber except it is set up on the ground, as at SAKO's Sundsvall, Sweden plant. Potroom gases are drawn from the roofs and forced down through a tower, then up where they contact downflow water on a grid packing. SAKO has installed a different device on the same plant but the principle is essentially the same. SAKO claims 70% removal of solids and 87% of fluorides and 67% SO_2 reduction (20).

Montecatini Edison's Italian plants control secondary emissions with roof-supported units mounted at one edge of the building. Gases are passed through two screens with water sprayed counter currently onto the screens. Fluorine removal of 70% and solid removal of 50% are attained (18).

The Mosjoen Aluminumverk, Norway, has had a secondary system in use since 1958, but in 1970 replaced it with a new system. This newer unit is ground supported and is much like others in several respects. Potroom gases are taken from the roof monitors and ducted into the bottom of the towers. Fresh sea water is sprayed

Table 6a
Emission Compairsons - Primary System

			Emissions Adapted to AAC			
	Efficiencies		Particulates		Fluorides	
System	Part.	Fluorides	#/ton	#/day	#/ton	#/day
AAC uncontrolled	0	0	31.8	15,900	47.7	23,850
AAC existing MC & VS	93.7	98.8	2.0	1,000	0.58	290
Martin-Marietta BS & WESP	99	99.66	0.32	160	0.16	80
Alcoa 398	98	99	0.64	320	0.48	239
CFDS	99.3	98.2	0.22	110	0.85	425
Montecatini-Edison DESP & ST	99	99.6	0.32	160	0.19	95
SAKO-Sundsvall PB	78	97.5	6.99	3,495	1.19	595

Table 6b
Emission Comparison - Sec. System

			Emissions Adapted to AAC			
	Efficiences		Particulates		Fluorides	
System	Part.	Fluorides	#/ton	#/day	#/ton	#/day
AAC uncontrolled (existing)	0	0	12-16	6000-8000*	3.13	1515
Martin-Marietta SC	77%	83.4%**	2.8 3.7	1440 1850	0.52	260
SAKO-Sundsvall ST	70%	87%	3.6 4.8	1800 2400	0.41	205
Montecatini-Edison ST	50%	70%	6 8	3000 4000	0.94	470
Mosjoen Aluminumverk ST	50%	90%	6 8	3000 4000	0.31	155
Foamator	75	85	3 4	1500 2000	0.47	235

*Adapted to full production data from AAC data (14).
**Assumed 90% gaseous F, 10% part. F.

Table 6c
Overall Emissions Comparison

AAC - Intalco

	Total Fluoride	Total Particulate
Anaconda Aluminum	3.71 #/ton	14-18 #/ton
Intalco (1973)	1.03 #/ton	4.33 #/ton

down into wooden grids, countercurrent to the gas flow. Treatment efficiencies in the secondary system are 90% on total fluorides and 50% on particulates (22).

One other system deserves mention. Pechiney at one of their most recently constructed lines took a slightly different route. Instead of installing both primary and secondary control on the 130 KA prebaked anode pots, only one system was installed. The pot gases are vented to a roof scrubbing system along with ventilation air.

Potline layout and ducting is slightly different than usual. Pechiney claims over 90% removal of HF (21, 23). AAC notes in its comments on the draft statement that Pechiney later added a primary system because of problems experienced.

B. Cost of Control

The installation and operation of at least a primary air pollution control system and acceptance of the associated costs is now standard operating procedure for the aluminum industry. Those plants which employ secondary systems have accepted the costs, but secondary systems and costs have not been generally accepted by the industry.

Unfortunately data on the capital and operating costs of the systems are sparse and not particularly detailed, especially for secondary systems. Current data is even rarer. Most of the data, especially capital costs, are from 1970 or earlier. There are available though several indices which provide some indication of current costs relative to the costs of a few years ago. Chemical Engineering publishes a number of these indices, and the following table has been prepared from April 29, 1974, issue of that publication.

Chemical Engineering	1968	1970	1973*
Plant Cost Index (1957-59=100)	113.7	125.7	148.2
Construction Labor			162.0
Equipment & Machines			145.2
Buildings			155.0
Engineering			131.3

*As of December, 1973

	1968	1970	1973*
Marshall & Steves Equipment Cost (1926=100)	273.1	303.3	349.5
Process Industries Average			349.0
Mining & Milling			347.9
Electrical Power Industry			333.5

The cost data are presented here in terms of dollars per ton of annual capacity. This technique allows comparison of different size plants and is an accepted means for cost comparison. Where available, the data have been extrapolated to a total dollar figure for a plant the size of Anaconda Aluminum's.

Anaconda Aluminum has provided the state with limited (and unverified) data on the capital and operating costs of its system as it is now.

AAC says that, to date, capital costs are $5,960,032 or $33.11/capacity ton. Operating costs are reported as $1,000,000 or $5.55/ton. Capital cost data originally reported on an amortized basis, is given as such in this section. Otherwise the department has made no attempt to give amortized costs, because of the varying methods of amortization.

Of the secondary systems mentioned, the one installed by Martin-Marietta is probably the most direct indication of what Anaconda Aluminum might do. Both are similarly designed vertical stud plants, located in the same general geographic area of the U.S., served by the Bonneville Power Administration and close to the generating stations. The available data is from The Dalles plant which has 5 potrooms of about 1000 feet in length each containing 60 pots, with a total plant annual capacity of 91,000 tons of aluminum. Anaconda Aluminum's plant is approximately twice the size of the plant at The Dalles.

After completing modification of the MM system in late 1970, MM applied to the State of Oregon for tax relief. The total cost of the MM system as given in the application was $4,155,077.94. However, the Martin-Marietta system has no waste water treatment facilities. Estimates place water treatment facilities capital costs at $130 per gallon per minute to be treated (13). Assuming 25,000 GPM of scrubber water, the facilities cost about $2.3 million 1970 dollars.

The total cost for such a system at Anaconda Aluminum would be approximately $10.6 million or $58.80/ton of annual capacity.

The Pechiney plant at Nogueres, France, uses 100,000 amp VSS pots with a total annual capacity of 110,000 metric tons (121,000 short tons). Air volumes are somewhat lower than encountered at Anaconda Aluminum. Total cost of the primary, secondary, and fluoride recovery system has $5 million for 3 lines of cells, equivalent to about $41 per capacity ton to achieve approximately a 93% overall collection efficiency on fluorides (21). Between 1962-1970 SAKO's Sundsvall plant invested $4.25 million ". . . as investments made for controlling and minimizing the influence from the plant on the environment." This plant has a present output of approximately 66,000 metric tons per year (78,600 short tons per year) or a cost of $54 per ton of capacity. This includes cost for both primary and secondary systems. Overall efficiency for the whole system is 72% on particulate matter, 95% on fluorides and 79% on sulfur dioxide (20). The Montecatini Edison plant reports its total air pollution systems installation costs were 2 lire per kilogram of aluminum, operating costs were 5 lire per kilogram of aluminum and total expenditure was 7 lire per kilogram of aluminum based on capital and interest amortization of 15 years at 8½%. System efficiencies in the primary system are 99% on solids, 99.6% on total fluoride and in the secondary system 50% on solids, and 70% on total fluoride (18).

AAC has provided very limited cost projections for the foam system. Some suggested estimates place the control cost of one potroom at $1.45 million. If costs were similar for the rest of the plant, total capital costs would be about $14.5 million, which apparently does not include costs for water treatment, which would be low because of the small volume to be treated. It is assumed that capital costs per unit capacity would be less on plant-wide installation than on the experimental prototype, but the above figure equates to about $80.70/capacity ton.

In 1970 the Mosjoen Aluminumverk in Norway replaced their old system with a new one. They reported capital costs of $4.5 million and operating costs of $350,000 per year for this system. Total plant capacity is 90,000 metric tons (99,000 short tons) per year, resulting in an installed capital cost of about $45.50 per capacity ton (22). This plant doesn't employ a water treatment system. If such a system were to be installed, the cost figure would almost double.

C. Compliance

At present AAC is subject to 3 regulations, wholly or in part. These emission regulation restrict the discharge of fluoride, particulate matter and visible emissions.

Currently, Anaconda Aluminum seems to be in compliance with S1460, visible emissions. They are probably in violation of S1430, regarding particulate matter, and they definitely and continually violate the limitations set in S14080 which covers aluminum plant fluoride emissions.

The department has proposed a modification of the regulations relating to the emission of particulate. The presently applicable rule, known as the "process weight law," relates allowable discharge to material processed in a single process unit. A problem arises in trying to define a process unit of an aluminum smelter. Depending on interpretation the rule would have allowed AAC to emit somewhere between 2.25 to 25.25 #/TAP. To clarify the definition and state the emission limits unequivocally, the department has proposed that aluminum plants be exempted from the process weight law, and that a provision be added to S14080 regarding particulate emissions. This provision as proposed would limit particulate emission to 0.33 # per hour per reduction cell, equivalent to 9.4 # part/TAP or 4700 #/day at full production. This appears to be the best interpretation of the process weight regulation for application toan aluminum reduction plant

Compliance with this limit would require a reduction between 27% and 45% of particulate emission. The degree of control that would be required of AAC would depend upon how much particulate the plant generates, which is not now known. Table 7 summarizes the allowable emissions, current emissions, compliance status and necessary reductions.

The fluoride restrictions as stated in regulation S14080 are 0.06 pounds of fluoride per hour per pot. This is approximately 1.73 pounds of F/TAP, at full production or 864 lbs/day. Current fluoride emissions, according to AAC's last report (14), averaged 3.78 lbs/ton or a full production equivalent of 1880 lbs/day. Compliance therefore requires approximately a 54% reduction in fluoride emissions.

The plant is apparently in compliance with a visible emission restriction of 20% equivalent opacity.

Table 7

Quantity Pollutant #/Day	Fluoride	Particulate	Visible
Allowable	864	4700*	20%
Actual Emission	1880	6500-8500	10%
Compliance (% reducation if necessary)	No(54)	No(27-45)	Yes

*As Proposed

Compliance with the established and proposed standards would necessitate certain emission reductions. Section A describes the technology which exists to control the emissions from the roofs of aluminum plants and the systems which would, it seems, achieve compliance with Montana's standards if installed at AAC's Columbia Falls plant. Section B describes the cost for such systems.

The state should not and does not suggest that AAC employ any specific engineering configuration of air pollution control systems, and does not contend that any such system including those mentioned as an "off the shelf" item. Modifications and improvements necessarily would require time to effect any system for compliance. A timetable by which compliance with the particulate emission provisions are to be achieved is as follows:

(i) Not later than July 31, 1974 - Submit to the administrator a final control plan which describes, at a minimum, steps which will be taken to achieve compliance

(ii) Not later than December 31, 1974 - Conclude negotiations for and execute all necessary contracts for emission control systems or process modifications in compliance with final control plan

(iii) Not later than March 31, 1975 - Initiate on-site construction or installation of emission control systems or process modifications

(iv) Not later than May 31, 1976 - Complete on-site construction and installation of emission control systems and process modifications

(v) Not later than July 31, 1976 - Achieve compliance and certify such compliance to the administrator

(vi) Within five days after the deadline for completing increments (ii) through (v), certify that each increment was met

Copies of all present and proposed regulations are appended in A

IV. EXISTING ENVIRONMENT AND POLLUTANT EFFECTS

A. Topography

Anaconda Aluminum Company's Columbia Falls plant is located in Northwestern Montana, about 2 miles ENE of Columbia Falls, in Flathead County. The plant sits at the base of the barren Teakettle Mountain in the Whitefish Range of the Rocky Mountains. To the south the Flathead River flows westerly from Hungry Horse Reservoir towards Kalispell and Flathead Lake. To the north the Whitefish Range bends toward the west forming the northern boundary of the Flathead Valley. The western boundary of the Flathead Valley is the Salish Mountains.

Elevation at Columbia Falls is 3037 feet (MSL) and Kalispell 2936 feet (MSL). Elevations in the vicinity are quite varied given the proximity of Glacier National Park with Mt. Cleveland at 10,440 feet. Glacier National Park lies north and east of the plant with the nearest point less than 6 miles northeast. The mountains bounding the valley generally range from 5000 to 7000 feet.

There are numerous mountain streams and lakes in the area, in addition to major bodies of the Flathead River and Flathead and Whitefish Lakes. The Hungry Horse Reservoir, created for generating hydroelectric power, lies a few miles SE of the plant and provides 148,000 KW or 40% of AAC's power for operation of the plant. The valley lies at the upper end of the Columbia River drainage basin.

B. Population

The largest town in the area is Kalispell with a 1970 population of 10,526. Columbia Falls has a population of 2652. Other towns in the area have populations as follows:

Whitefish	3349	Hungry Horse	700
Olney	250	Martin City	500
Somers	889	Coram	500
Lakeside	600	Kila	48
Bigfork	500	Rollins	100
Creston	25	Apgar	20
Marion	150		

The aggregate total of this urban population is 20,809. The total rural and suburban population of Flathead County is 18,650. The total county population is 39,460.

C. Land Use - Social Setting

A large portion of the total area of Flathead County is taken up by Flathead Lake and rugged mountains. Conventional agricultural pursuits such as cattle raising and crop farming are pursued, particularly in the "lowlands." Much of the mountainous country is forested and contained within national forest boundaries and some additional forest is controlled by the state and by private interests. Use of the forest constitutes one of the major land uses in the area. The wood products industry, primarily sawmilling, is a large user of the forests and a large employer in the valley.

Agriculture found in the valley is quite varied. The Flathead Valley, especially the east shore of the lake, is well known for its cherry crops. The north end of the lake has a considerable amount of Christmas tree farming, corn raising, and wheat ranching. There are some 1200 farms and ranches in Flathead County.

In the valley Anaconda Aluminum is the major heavy industry. There are a few secondary manufacturing and fabricating industries found, deriving their input materials from locally available sources, primarily sawmills.

In general, western Montana is oriented toward the wood products industry as opposed to the agricultural leanings east of the continental divide. Consistently the social settings of the two areas differ, though not greatly. Low population densities, moderate incomes, a certain remoteness all lend themselves to a life style considerably different from larger metropolitan areas. A greater association with outdoor activities and generally low-keyed relationships characterize the day to day living of area residents.

Another prime use of the land in the Flathead Valley as in much of Montana is recreational. Many of the recreational pursuits provide a dual use of the forests. The usual range of recreational activities such as hunting, fishing, camping, boating, hiking, snowmobiling, skiing, are practical to varying extents throughout the area.

In light of the recreational activities found, it is not surprising to find that tourism is a major item of commerce for the area. Both summer and winter offer opportunities to visitors of the area. Glacier Park is a large drawing card for the Flathead Valley and the area provides a close and reasonably complete source of goods and services for those visiting the park. The prime attraction of Glacier is its scenic beauty; rugged mountains, diverse and plentiful vegetation and clear skies. Healthy forests are necessary, not only for their aesthetic values, but as food and habitat for animals and proper operation of the ecosystem. The forests are becoming increasingly important as other areas of the country, even in Montana, feel the effects of population and pollution. Forest damage occurring in the park and the national forests is discussed later.

D. Meteorology and Climatology

The following, courtesy of the U.S. Department of Commerce, National Oceanic & Atmospheric Administration, Environmental Data Service, is a narrative climatological summary of the Flathead Valley. The weather service station is located at Glacier Park International Airport between Kalispell and Columbia Falls.

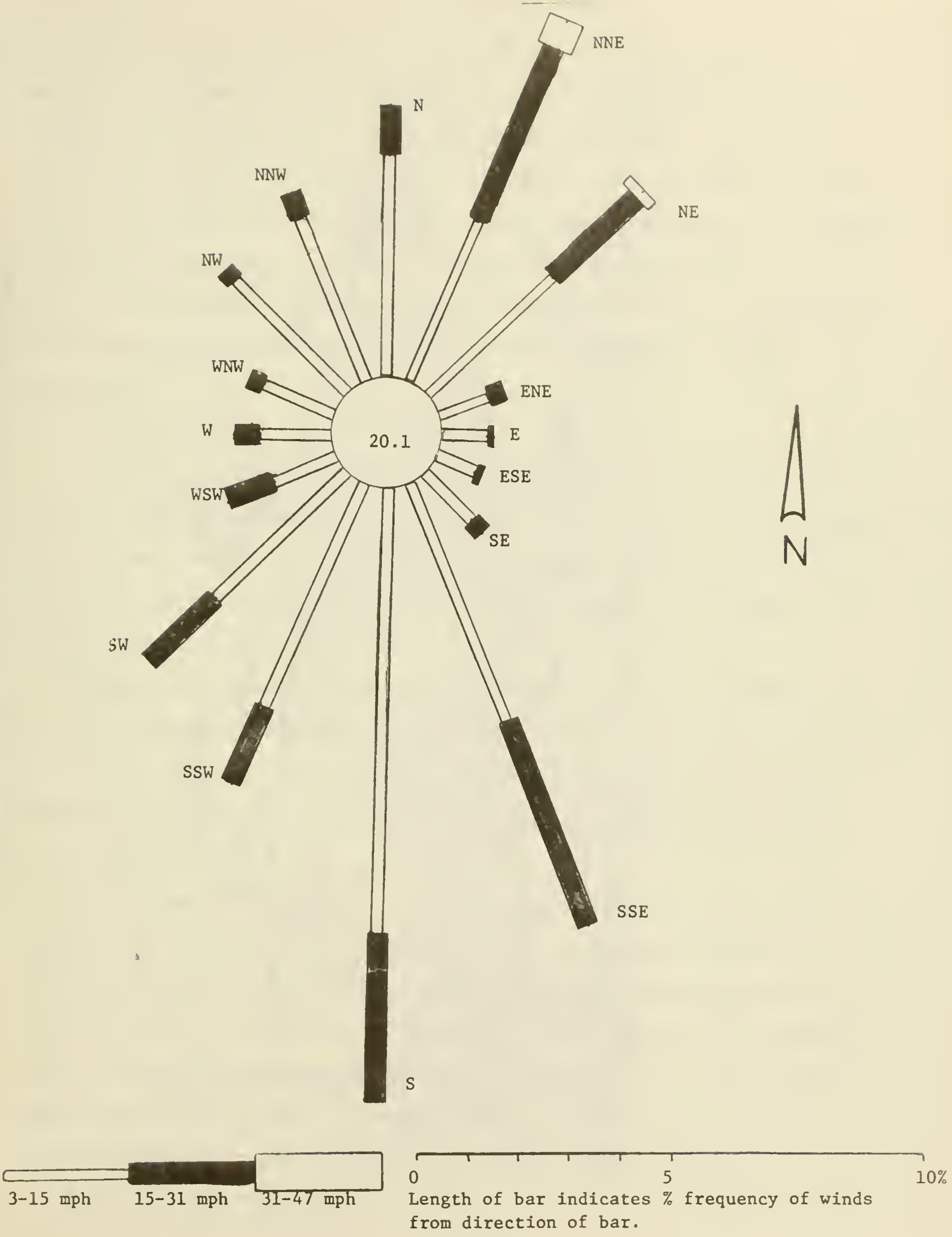
> "Since the climate of the Flathead Valley differs materially from that just east of the Continental Divide (The divide is approximately 40 miles to the east of the station), it can principally be attributed to the influence of the topographical features. The high mountains to the east form an effective barrier to many severe winter cold waves that move down over sections east of the Rockies from Alberta. The mountains to the east rise abruptly 4,500 feet above the valley floor. Their elevation and snow remaining on the crests until late spring assure frequent and beneficial rains by cooling of moist air moving from the west.
>
> "In addition to Flathead Lake, the valley contains four smaller lakes, three rivers, and numerous streams and sloughs. Until late in the winter when a large portion of the lakes and sloughs become frozen over, this water surface tends to limit temperature extremes. This effect is most noticeable in the southern end of the valley, because of more influence of Flathead

Lake. Due to its size, Flathead Lake seldom freezes over.

> "The weather at the airport is considerably different in some respects from the weather in Kalispell. Generally there is more cloudiness at the airport since it is closer to the mountains to the east and north. Moist air moving in from the west and southwest, lifting and cooling as it moves over the mountains, is the major cause. In connection with this, there is averagely more precipitation on the east side of the valley than on the west side. Average snowfall during the winter at the airport is 67 inches and in Kalispell it is 49.4 inches.
>
> "Starting in March and lasting through September the prevailing wind from 11:00 a.m. until 7:00 p.m. is from the southeast. This wind blows off Flathead Lake and is caused by the land surfaces heating more in the daytime than the water surface of the lake. This wind is very noticeable both at Kalispell and the airport, often reaching 20 m.p.h. and occasionally quite gusty. There are, of course, times when the wind during this period is not from the southeast. Other effects such as cloudiness, frontal passages, etc., may cause the wind to be from another direction. The year around prevailing wind direction at Kalispell is from the west, at the airport it is from the south. Wind speeds average considerably stronger at the airport than in Kalispell.
>
> "In the winter, when a cold wave moving down the east side of the Continental Divide does come through the mountains, the airport is in direct line of the pass the cold air comes through. During these cold waves the wind is from the northeast and will usually have speeds reaching 50 to 60 m.p.h. The strongest gust reported during one of these storms was 84 m.p.h. As the cold air moves down the valley it spreads out, decreasing the wind velocity, and mixes with the warmer air of the valley. Unless these cold strong winds persist for 3 or 4 days, the wind in the lower part of the valley will be from the northwest, because of the influence of Flathead Lake and the mountains to the west. This wind is always much stronger in the northeast end of the valley where the airport is located than any other place in the valley. In the northwest corner where Whitefish is located, and in the southeast part of the valley, there is rarely much wind from this storm."

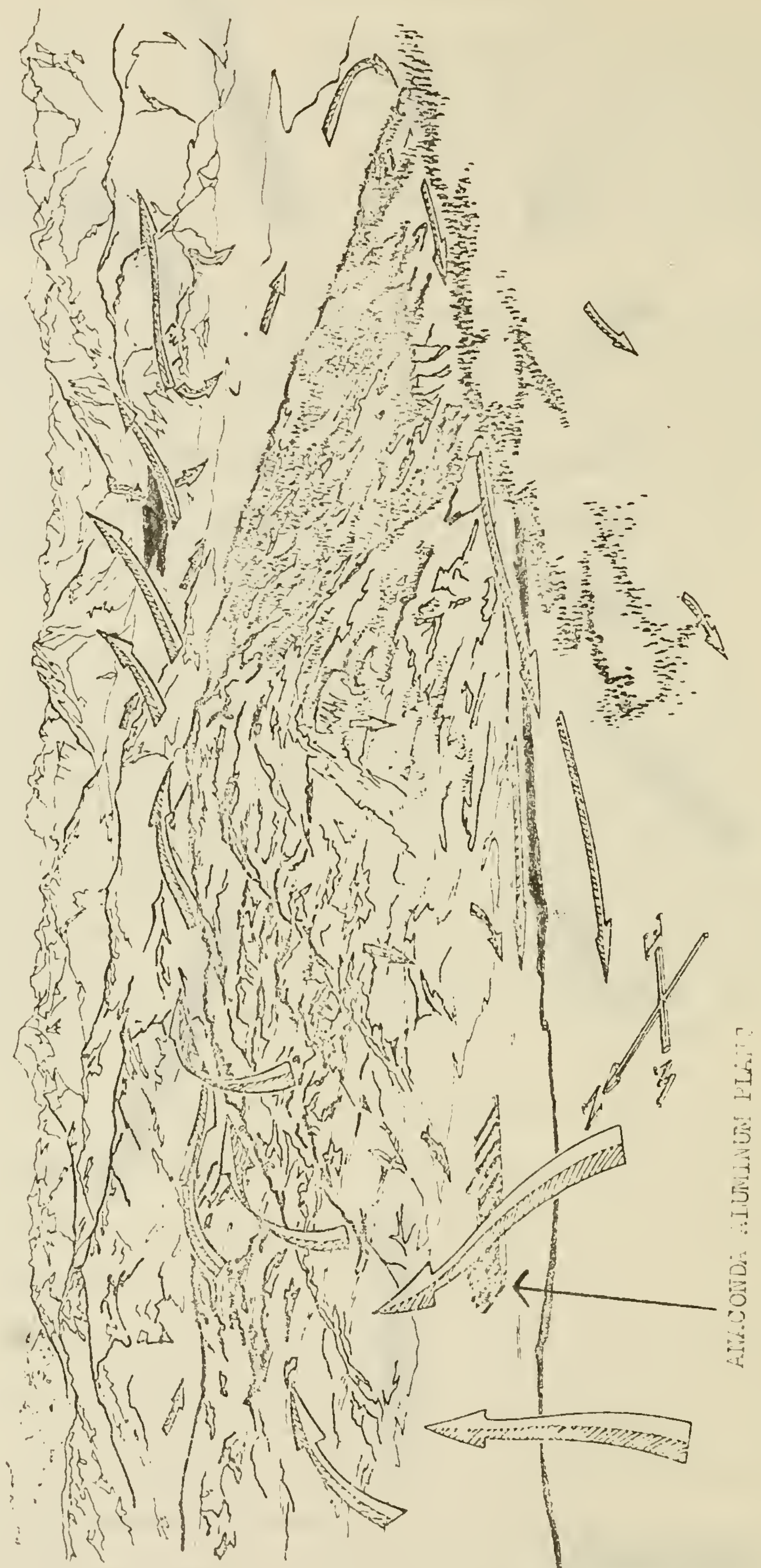
Annual precipitation averages 15.42 inches compared with a total of 14.63 in 1972. Snowfall at the airport averages 67" per year with a 1972 total of 76.1". The following wind rose, Figure 2, has been prepared from the most current wind rose in use by the weather service.

The Environmental Protection Agency (EPA), formerly NAPCA, recently released a report on fluoride studies conducted in and around Glacier Park (24). The report postulated that diurnal variations in wind have a significant effect on fluorides reaching the park. Nighttime winds flow from the east to west out of



Length of bar indicates % frequency of winds from direction of bar.

FIGURE 2



Simplified drawing of typical midmorning wind-flow patterns in Upper Flathead Valley.

FIGURE 3

Badrock Canyon but currents are not strong. The patterns are depicted in Figure 3. Nighttime plant effluent is not diluted by wind as much as daytime emissions, so it accumulates in the air in the plant vicinity. The effluents rise but have insufficient buoyancy to reach the crest of the mountains. During the days, prevailing winds to the northeast carry daytime emissions and accumulated nighttime emissions over the saddle in Teakettle Mountain toward Glacier Park. This effect is most pronounced around mid-morning; later in the day the accumulation of pollutants has been removed and only that day's current emissions move over the mountain.

E. Air Quality

Levels of various pollutants in the ambient air in the Columbia Falls area continue to exceed various state and federal standards frequently, although levels have declined somewhat in recent years. Table 8 presents the state and federal ambient air standards for particulate matter and fluorides. Also included in the table are 1973 sampling results.

The data definitely demonstrate that reduction in the levels of pollutants is required to achieve the ambient air standards. Emission reductions probably will be necessary in varying degrees from all emission sources, including Anaconda Aluminum, the wood products industry, and municipal and urban sources such as dusty roads.

Table 9 summarizes particulate sampling at two stations for 1971 to the present. (See Appendix B for site description). Data reported are monthly geometric means in micrograms per cubic meter (ug/m^3). The data includes high and second high individual readings and the number of violations of the Montana 24-hour standard. The EPA has employed a diffusion model to extend the ambient particulate levels resulting from AAC's particulate emissions (24). The model predictes a maximum 24-hour average of 730 ug/m^3 on Teakettle Mountain.

Table 10 presents the state's data on ambient fluoride levels obtained from calcium formate papers. The formate paper technique is a relatively simple but effective means of determining average concentrations of fluoride in the ambient air. The technique however does not allow recording of peak short-term values for fluorides but has been shown to provide some indication of the exposure of plants to fluorides. Table format indicates the average for the period, the maximum reading obtained during the period and the number of violations and the number of months data included in the period. The stations included in the table are generally those stations which experienced higher readings but a Columbia Falls station also has been included. Perhaps most useful are the three stations for which the state has accumulated 5 years of data. It is significant that at 2 of the 3 stations values are still exceeding state standards by substantial margins although it is apparent that some reductions have occurred over the past few years. Some of the Teakettle Mountain stations are subjected to extreme levels of fluorides, at times exceeding the state standard by a factor of 30. The limited sampling from recently established Glacier Park stations have been below the standard for gaseous fluoride, but the vegetation in the park continues to accumulate significant quantities of fluoride and damage continues to occur. Further discussion on this can be found in the subsection on vegetation. The organization known as The National Air Pollution Control Administration (NAPCA), now part of the EPA, sampled in the area for fluorides to obtain data for a report on fluoride pollution in Glacier National Park. The report in general substantiates the state's data (24). A copy of EPA data and site identification is included in Appendix B.

Anaconda Aluminum has sampled and continues to sample the air for total fluorides. Samplers are located at several locations around the plant, using sodium bicarbonate tubes as the sampling device. Appendix E contain graphic summaries of AAC's data since early 1970 and some selected raw data as submitted

Table 8

AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Period	State of Montana Standard	U.S. EPA Standard	1973 Sampling
Total Suspended Particulate	Annual Geometric	75 ug/m^3	60 ug/m3	70 ug/m^3 (0270002)
	24-hour	200 ug/m^3 (a)	150 ug/m^3 (b)	457 ug/m^3 (0270002)
Fluorides Total As (HF)	24-hour	1 PPB (c)	-	3.75 PPB
Gaseous	28 days	0.3 ug/CM2 - 28 days		
	30 days (d)	0.321 ug/CM2 - 30 days		10.850 ug/CM^2-30 days (0480015)

(a) Not to be exceeded over 1% of days in a year
(b) Not to be exceeded more than once a year
(c) PPB - volume, parts HF per billion parts air
(d) Standard is for 28 days
Computerized data reported for 30 days

(Site ID)

Table 9

TOTAL SUSPENDED PARTICULATE
ug/m^3

Month	High School 1971		High School 1972		High School 1973		High School 1974		Dehlbom's 1973	
	Geom. Mean	hi/2nd hi	Geom. Mean	hi/2nd hi	Geom. Mean	hi/2nd hi	Geom. Mean	hi/2nd hi	Geom. Mean	hi/2nd hi
Jan			N.D.		51 (1)*	253/138	17 (0)*	46/42		
Feb			21 (0)*	74/32	53 (0)	103/38	27 (0)	148/42		
March			68 (0)	196/32	109 (3)	457/204				
April	101 (0)*	191/176	40 (0)	196/108	94 (1)	281/167				
May	159 (1)	221/154	57 (1)	248/112	108 (1)	238/198			37 (0)	72/68
June	91 (4)	255/246	85 (2)	221/217	66 (0)	143/135			32 (0)	73/62
July	258 (9)	474/441	106 (a)	126/110	93 (0)	142/114			54 (0)	127/121
August	164 (4)	329/328	125 (2)	240/224	80 (0)	132/121			59 (0)	143/135
September	139 (3)	390/294	105 (1)	276/184	54 (0)	103/94			25 (0)	61/57
October	205 (5)	447/352	504 (1)	504	56 (1)	216/149			32 (0)	69/43
November	221 (2)	229/214	116 (2)	256/227	34 (0)	117/33				
December	N.D.		40 (1)	283/196	32 (0)	51/49				
Annual Cumulative	153 (27)	474/447	69 (10)	504/283	70 (7)	457/281			40 (0)	143/135

*Numbers in parentheses refer to number of violations of Montana's 24-hour standard recorded during the period.

Table 10

Calcium Formate Papers
Selected Stations
F ug/cm^2 - 30 days

Average / Maximum   Number of Violations / Number of Months Data

Station	1974		1973		1972		1971		1970		1969	
136 9th Avenue	0.155	0	0.232	3	0.242	2	0.539	6				
0270001	0.190	2	0.470	12	0.700	12	1.200	8				
Dehlboms	0.250	1	0.401	6	0.881	12	1.097	10	1.048	9	4.335	8
0480002	0.360	2	0.870	11	1.640	12	2.100	11	1.500	9	9.080	8
Feirstein	0.215	0	0.331	6	0.542	8	0.771	10	0.699	8	1.617	7
0480003	0.230	2	0.620	12	1.120	12	1.500	11	1.200	9	3.100	8
Badrock Substa.	0.240	0	0.165	0	0.412	9	0.460	9	1.163	7	1.244	8
0480005	0.240	2	0.250	12	0.610	12	0.730	11	4.800	9	3.780	0
Dehlbom's Field	0.215	0	0.419	6	1.064	8						
0480013	0.230	2	0.980	11	2.700	8						
Anaconda So.	3.570	1	3.213	12	8.570	7						
0480013	3.570	1	5.560	12	10.070	7						
Teakettle Mtn.			5.408	6	7.451	7						
#2 0480015			10.850	6	12.070	7						
Teakettle Mtn.			2.861	10	5.375	4						
#6 0480019			3.880	10	15.730	4						
Teakettle Mtn.			0.217	0								
#8 0480022			0.310	8								
Glacier Park #1			0.073	0								
0570003			0.080	3								
Glacier Park #2			0.140	0								
0570004			0.160	3								

by AAC for recent months. Levels as high as 3.75 parts per billion (PPB) have been recorded as recently as October 9, 1973. This is almost 4 times the state standard for fluoride as HF. In total for 1973, AAC reported some 80 violations out of 1469 total samples, even though production and fluoride emissions were lower than usual during most of 1973. In January, 1974, they reported 10 violations of 148 samples.

Between June 1963 to June 1964 the State Board of Health, Division of Disease Control conducted a study on suspended particulate and polynuclear aromatic hydrocarbons (PAH) at Creston, Kalispell, and Columbia Falls (26). The study is somewhat dated, but no more recent data are available. Analysis was performed on suspended particulate for variety of PAH compounds such as benzo-a-pyrene, fluoranthene, coronene, etc., which have been implicated as cancer producing agents. Results indicated that the ratio of PAH to the benzene soluble organic material in the particulate was considerably higher in Columbia Falls than in Kalispell, and Kalispell was higher than Creston. The ratio of total PAH to total particulate was considerably higher in Kalispell and Columbia Falls than in Creston, and Columbia Falls was slightly, but insignificantly, lower than Kalispell. Perhpas the most important factor is the total PAH in the ambient air expressed in micrograms per 1000 cubic meters. For example, Creston has 11.1 ug per 1000 cubic meters, Kalispell 25.6 and Columbia Falls experienced 40, a significant difference. Also total suspended particulate levels at this time were as much as 3 times as high in Columbia Falls as those in Kalispell or Creston.

F. Human Health

FLUORIDE

Much of the work done relating fluoride intake to effects on the body has dealt primarily with ingested fluoride; i.e., F content in water and food. Some work has been done in relation to establishing occupational exposure levels, but very little research has been done relating ambient air concentrations to effects on humans.

Hydrogen fluoride gas is a pulmonary irritant but more damage occurs in the calcified structures (bones and teeth). Other effects may include loss of body weight and inhibition of production of certain enzymes (27).

Table 11 (28) summarizes the effects of fluorides on humans. The data in that table are practically the only published data available but are subject to question.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes allowable limits for occupational exposures. If one notes from Table 10 an average daily intake of 0.2-1.2 milligrams (mg), an 8-hour HF concentration of 2.5 mg/M^3 permits an intake of 25 milligrams assuming 10 M^3 air inhalation in 8 hours. However, Montana's ambient air standard is one ppb (0.8 micrograms per cubic meter (ug/M^3)), which permits a daily intake of 16 ug or .016 mg, assuming 20 M^3 inhalation in 24 hours. A figure of 25% absorption has been used but not documented. From these data it appears that an ambient air standard such as one ppb allows a fluoride intake amounting to somewhere between 0.25 and 2% of the average daily intake.

It has been observed that fluorides, like mercury, are concentrated in the food chain; therefore, persons residing under the influence of fluoride emissions may accumulate significant quantities in the body from water, locally raised fruits, vegetables, and livestock. Occupational exposures also could contribute to the total dose (29).

PARTICULATE

Particulate matter has been linked to health effects on man. The effects are largely those relating to the respiratory system. The observed high values (24-hr.) of suspended particulate in Columbia Falls area may be exposing residents to unnecessary risk, as will be seen later.

Table 11

Mean Concentration HF in air mg/m^3	Total F in Ration, Diet or water mg/kg	Mean Daily Intake Milligrams (MG/Day)	Duration	Effect
≳ 0.1	-	-	Single Exposure	perceptible odor conc. for HF
2.5			Daily	TLV 8 hr. ACGIH
≈25			Single Exposure	tolerable, with conjunctival and respiratory discomfort only for several minutes
≈100			Single Exposure	highest tolerable conc for 1 min marked conjunctival and respiratory irritation
		0.2-1.2	Daily	avg. daily intake, USA Food and Water
	2-8 (water)		Years	mottled enamel (formative years)
	40		Several Years	loss of body weight
	50		Months-Years	thyroid injury*
	100		Months	renal injury*
		20-80	10-20 Years	crippling fluorosis
		2,500-5,000	Single Dose	death in 2-4 hours

*Based on data from animals extrapolated to man. Reference 28.

NAPCA publication #AP-49 (30) states: "Particulate matter may exert a toxic effect via one or more of three mechanisms:

1. The particle may be intrinsically toxic due to its inherent chemical and/or physical characteristics;
2. The particle may interfere with one or more of the clearance mechanisms in the respiratory tract.
3. The particle may act as a carrier of an adsorbed toxic substance."

The following tables were extracted from a report prepared by the health effects personnel in EPA National Environmental Research Center at Research Triangle Park, North Carolina. In light of the health effects observed in Tables 12 and 13, thresholds were estimated to prevent such effects from occurring or to minimize the effects on the total population, according to EPA. The safety margin included in the standards is negligible for the 24-hour standards but amounts to about 33% over the annual averages (Table 14). A sizeable portion of the population will be subjected to risk of symptomatic occurrence of various adverse effects (Table 15).

Possibly more significant is the presence of polynuclear aromatic hydrocarbons (PAH) of a carcinogenic nature (benzo-a-pyrene, benz-k-fluoranthene, etc.). The coal tar pitch used as anode paste at Anaconda Aluminum contains significant quantities of PAH. In fact, coal tar pitch ". . . is composed almost entirely of polynuclear aromatic compounds . . . Hazard: highly toxic by inhalation." (32)

An extensive literature review, Preliminary Air Pollution Survey of Organic Carcinogens, NAPCA publication APTD 69-43, states that "a correlation between the incidence of cancer and any single suspected environmental factor is extremely difficult to establish as well as quite limited in usefulness." (Emphasis supplied) (33). Nevertheless, there exists a well accepted correlation between increased lung cancer incidence and exposure to polluted air. Several researchers, in attempting to establish atmospheric carcinogen-lung cancer correlations, concluded that such correlations existed. Kotin and Flak, Ref. 121 in the above mentioned publication, reasoned as follows:

Table 12
(31)

Adverse Health Effects	Concentration at which effect was observed Concentration (ug/M^3)	Averaging Time
1. Increased mortality	750 or a rise of 200	24-48 hours
2. Increased infant mortality & cancer deaths.	200	3 days
3. Increased upper respiratory infection and cardiac morbidity.	375*	24 hours
4. Excess bronchitis mortality	200	24 hours
5. Actue worsening of symptoms in bronchitis patients	300	Daily
6. Increased mortality from chronic respiratory disease & all causes.	100	2 years
7. Increased chronic respiratory disease prevalence in adults; increased upper & lower respiratory tract disease & diminished pulmonary function in children.	100-200	Annual

*converted from 3 COH units (let 1 COH = 125 ug/M^3

Table 13
(31)

Adverse Health Effect	Concentration at which effect was observed Concentration (ug/M^3)	Averaging Time
1. Increased cough, chest discomfort & restricted activity	100-269	24 hours
2. Aggravation of cardio-respiratory symptoms in health persons, & in elderly patients with heart & lung disease; increased asthma attachs in people with asthma.	80-100	24 hours
3. Aggravation of cardio-respiratory disease symptoms in elderly patients with heart or chronic lung disease.	76-260	24 hours
4. Decreased pulmonary function in school children.	110	Annual
5. Increased frequency & severity of acute lower respiratory disease in school children.	100	Annual
6. Increased chronic respiratory disease symptom prevalence in adults.	100	Annual

Table 14
SAFETY MARGIN INCLUDED IN TOTAL SUSPENDED PARTICULATE STANDARD (31)

	Concentration in ug/M^3		
Adverse Effect	Threshold Estimate	Primary Standard	Safety* Margin (%)
1. Excess mortality	250-300 100-175	260 (24 hr) 75 (annual)$^+$	None 33 to 133
2. Aggravation of symptoms in elderly	80-100	260 (24 hr)	None
3. Aggravation of chronic lung disease	250	260 (24 hr)	None
4. Aggravation of asthma	100	260 (24 hr)	None
5. Acute irritation symptoms	170	260 (24 hr)	None
6. Decreased lung function in children	100	75 (annual)	33
7. Increased prevalence of chronic bronchitis	100	75 (annual)	33
8. Increased acute upper & lower respiratory illness in families & in school children	100	75 (annual)	33

*Safety Margin = $\frac{\text{Threshold-Standard}}{\text{Standard}}$ x 100

+Geometric mean

Table 15
ESTIMATED POPULATION AT POTENTIAL RISK TO POLLUTANT-INDUCED EFFECT (31)

Adverse Health Effect	Expected Proportion of the Population at Risk (Rate per 100)	Expected Size* of Population at Risk
1. Mortality	23+	32,220,000
2. Symptom aggravation in elderly	23+	32,220,000
3. Aggravation of chronic lung disease	20 to 40	28,000,000 59 56,000,000
4. Aggravation of asthma	3 to 5	4,200,000 to 7,000,000
5. Acute irritation symptoms	100	140,000,000
6. Decreased lung function in children	20++	28,000,000
7. Increased prevalence of chronic bron.	100	84,000,000
8. Increased acute respiratory diseases	100	140,000,000

*assumes 70% of 200,000,000 persons live in U.S. urban areas

+proportion of population aged 50 or more

**proporation of population aged 20 or more

++proporation of population aged 5 to 14

> "(1) Carcinogenic agents have been identified and quantified in the polluted air of essentially every city in which they have been sought;
>
> (2) Similarly, chemical compounds with known tumor-promoting properties have been identified and quantified in polluted urban air;
>
> (3) The stability and survival of carcinogenic hydrocarbons in the atmosphere are compatible with inhalation and a postulated biological effect in those exposed;
>
> (4) Carcinogenic agents, as well as noncarcinogenic respiratory epithelial irritants, occur in the atmosphere in a state compatible with host entry and tracheobronchial deposition;
>
> (5) Alteration in function and structure of the respiratory epithelium of respresentative mammalian species has been demonstrated following exposure to a broad spectrum of these environmental irritants. The resulting changes appear to facilitate the biological action of carcinogenic agents; and,
>
> (6) Bioassay by skin-painting and subcutaneous-injection techniques has established the carcinogenic properties of compounds identified in and extracted from polluted air. Exposure of both susceptible and resistant strains of mice to aerosols of synthetically reproduced polluted urban air has resulted in lung tumors in both strains."

A further occupational hazard associated with the use of coal tar pitch is photosensitization. Combes, at New York University, states (34) that workers using coal tar as an insulating material developed itching and dermatitis on areas of the skin exposed to the pitch after subsequent exposure to sunlight. Similar conditions exist at the Columbia Falls plant.

Recalling the results of the studies of PAH in Columbia Falls, it seems appropriate to prevent the subjection of residents to the risks associated with exposures to PAH in the ambient air.

G. Animals

That atmospheric emissions of fluoride can culminate in significant damage to livestock has been well documented. It is generally accepted, also, that a major source of fluoride causing fluorosis in animals is not inhalation but ingestion of contaminated feeds and possibly water. The fluoride content of grasses, other feeds, and water may depend on several sources of fluoride, including the soil. Fluorosis in cattle has been found in Tennessee where cattle were fed on crops grown in high fluoride soils in an non-industrial agricultural area. Fluoride in the plants was due to wind blown dusts and splashing from heavy rainfall rather than uptake of fluoride in the soil by the plant.

Most studies regarding domestic livestock and the effects of fluoride on them have been done with cattle,which exhibit a greater tendency to accumulate the fluoride and develop some type of fluorosis than other livestock animals. The effects of fluorides on animals is much the same as the effects on man. The most susceptible portion of the population is the young--those with developing dentition and skeletal structures. The effects can be seen in older animals also, especially if they have been feeding on a contaminated forage for a long time.

To protect animals, the state has adopted a standard for fluoride content in forage of 35 ppm (dry weight basis). Much vegetation in the area has accumulated more than 35 ppm, sometimes several factors of ten in excess of that number.

Data are available on fluoride effects on wild herbivores; e.g., mule deer, whitetail deer, and rodents. Gordon (29) analyzed several animals collected around the AAC plant for the fluoride content in their bones. More than 650 animals were collected of which 95% were herbivores. Control species as a rule had an average of less than 200 ppm fluoride in the femur bones. The one exception was deer with an average level of 216 ppm, rarely exceeding 250 ppm in control animals. Of the 10 deer collected in the upper Teakettle Mountain area, during the study period, summer and fall of 1970, most manifested tooth damage and marked osteofluorosis of the femur bone. Mule deer and whitetail deer collected on lower Teakettle Mountain has fluoride contents ranging from a low of 370 ppm to a high of 7350, averaging 4168. Those collected on upper Teakettle had a low of 840 ppm, a high of 7150 and a mean of 3394. Generally it can be stated that fluoride content decreased with distance from the Anaconda Aluminum facilities. It is not surprising, given the levels of fluoride found in some of the vegetation and considering that the indigenous animals have no outside feed supplements, that fluoride is accumulating in the animals.

Similar results were obtained from animals gathered in the Park and similar conclusions were drawn. Fluoride contents were lower but still high. Four whitetail deer collected in Glacier Park averaged 1226 ppm F (high 2400, low 124) compared to the control animals (avg. 218, high 635, low 88).

These data dramatically illustrate the potential for damage, even the probability of current damage to wildlife residing under the influence of the AAC plant's emissions. The data further indicate the need to establish the extent of damage occurring as a result of the plant's emissions, and then to ensure safe exposure and intake levels to avoid damage.

H. Vegetation

There is extensive agriculture carried on in the Flathead Valley. The northern end of the valley where the Anaconda Aluminum plant is located has farming and livestock growing. This region of the valley is best known, however, for its recreational value. The mountainous environs exhibit a rich flora of predominantly coniferous forests. These provide excellent hunting, fishing, hiking, snowmobiling, skiing, and camping.

Among the trees most common to the area are:

Douglas Fir, Pseudotsuga menziesii (Mirbel) Franco

Ponderosa Pine, Pinus ponderosa Lwas

Balsam Fir, Abies lasiocarpa (Hook) Nutt

Whitebark Pine, Pinus albicaulis Engelm

Lodgepole Pine, Pinus contorta var. lacifolia engelm

Estern Larch, Layix occidentales Nutt

Yew, Taxus brevifolia Nutt

Juniper, Juniperus occidentalis Hook

Western Red Cedar, Thuja plicata Donn. Hort

Common deciduous plants of the region include:

Paper Birch, Betula papyrifera Marsh.

Mountain Maple, Acer glabrum Torr.

Cottonwood, Populus trichocarpa T and G., Ex. Hook

Aspen, Populus tremuloides, Michx.

Alder, Alpus incana (L) Moench

Mountain Ash, Sorbus scapulina Greene

If we compare the list of dominant trees found in the Columbia Falls vicinity with a list of those sensitive to fluoride (Table 16) it becomes obvious that the majority of plants in the vicinity of the aluminum plant are sensitive to fluoride. These plants are exposed to continual emissions of hazardous fluoride from the Anaconda Aluminum plant. The effects of fluorides on vegetation have been studied by scientists for years, so they are better documented than those of other pollutants. Aluminum reduction processes are know to be a source of hazardous levels of fluoride. Both gaseous fluoride and particulate fluoride dissolved by moisture are readily absorbed by plant foilage (35, 36). Once absorbed, the fluoride migrates to the tips and margins of leaves. When critical levels have been accumulated injury appears on needles of conifers or leaves of deciduous plants (37).

On deciduous trees the injury appears as necrosis of leaf tips and margins. This usually is delineated from healthy tissue by a dark band. The necrosis sometimes has a red tint. On conifers fluoride damage appears as tip necrosis, with the dead tissue often separated from health tissue by a dark band (29). The injury symptoms occur in areas of the plant which have accumulated toxic quantities of fluoride.

Table 16

FLUORIDE SENSITIVE PLANTS COMMON TO THE COLUMBIA FALLS ENVIRONS

Plant Species	Sensitive	Intermedite	Resistant
Douglas fir *Pseudotsuga menzeisii*	X		
Ponderosa pine *Pinus ponderosa*	X		
Lodgepole pine *Pinus controta* var. *latifola*	X		
Western larch *Laris occidentalis*	X		
Cedar *Thuja*	X		
Cherry *Prunus virginiana*		X	
Quaking aspen *Populus tremuloides*		X	
Serviceberry *Amelanchier alnifolia*		X	

Before damage can be labeled as fluoride induced, several circumstances must exist, as follows.

1. The presence of fluoride sensitive species.
2. The presence of a source of fluoride.
3. The presence of fluoride injury symptoms on sensitive plant species.
4. The accumulation of fluoride in plant tissue.
5. Discernible differences between these injury symptoms and those caused by other disease agents.
6. The presence of cellular abnormalities associated with excessive fluoride.

Each of these circumstances has been documented in the vegetation around Columbia Falls. The documentation comes from four sources: Anaconda Aluminum Company; State Department of Health, Air Quality Bureau; U.S. Forest Service; and Environmental Studies Lab, University of Montana. Table 17 includes data from a survey conducted by Anaconda Aluminum. The data have been segregated into pine and grass fluoride readings.

The table represents four years of seasonal data; 1970-1973, corresponding to collection sites located at various distances from the Anaconda Aluminum plant. The same sites were used from season to season over the four year span of this study. Note that the value corresponding to a particular season and distance from the plant is a mean for several collected samples. For example, the 17.20 ppm with an asterisk under the summer 1973 column is the mean fluoride content of five pine samples collected within one mile of the plant. Row B indicates the number of samples in violation within the seasonal sampling, while Row C indicates the two peak readings among the seasonal samples. Thus for the summer of 1970, 6 of 22 pine samples were in excess of the state standard of 35 ppm F. Of these 6 violations, the two peak readings were 107 and 72 ppm. Excessive levels continue to occur in samples collected, although this data shows a lowering of F levels in vegetation over the 4 years.

Table 17

Anaconda Aluminum Vegetation Data

Mean of Several Sites Per Mile Distance From Aluminum Reduction Plant

		1970			1971			1972			1973		
Distance		Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
A													
1 mile	Pine		42.1	53.5		24.2	47.2		18.6	40.4		17.2*	
2 mile	Pine		33.5	52.16		23.0	48.0		14.0	21.66		7.66	
3 mile	Pine		19.83	28.37		8.0	18.66		4.5	15.6		4.5	
4 mile	Pine		8.17	13.67		6.0	14.67		8.33	10.33		4.0	
5 mile	Pine	37.0	7.0	9.17		5.67	8.0		3.33	9.67		3.33	
7 mile	Pine		4.0	6.0		4.0	4.0		0	3.00		1.0	
9 mile	Pine		4.0	8.5		9.0	7.0		2.0	4.0		3.0	
B Total # violations/ Samples Collected		1/1	5/22	7/21		4/22	7/22		2/20	4/21		1/22	
C Peak Readings			107	131		42	88		38	77		31	
			72	90		42	77		31	56		23	
A													
1 mile	Grass		122.6	233.5	68.8	151.4	149.6	53.4	125.2	268.25	47.8	83.8*	
2 mile	Grass	22	71.83	75.25	31.67	60.0	92.0	30.5	35.67	106.33	18.67	24.0	
3 mile	Grass	12.5	27.7	41.0	15.5	23.0	48.17	10.33	7.67	32.4	6.67	14.5	
4 mile	Grass	20.5	22.83	29.0	22.67	26.67	67.0	7.67	7.67	27.0	6.67	18.33	
5 mile	Grass	10.0	24.67	40.33	9.67	16.0	44	3.67	13.33	18.33	3.33	9.67	
7 mile	Grass	9.0	24.5	45	19	22	17	6	13	29	6	15	
9 mile	Grass	7	14	33	8	22	13	3	2	9	4	9	
B Total # Violations/ Samples Collected		0/10	7/22	12/20	6/22	8/22	11/18	5/21	6/22	10/20	2/22	7/21	

*$_{\bar{x}}$ determination of ppm F in vegetation sample

C Peak Resdings	31.0	206	413.5	161	220	262	95	236	755	112	129	
		189.5	356	57	180	170	69	198	241	71	114	

Fluoride accumulates in vegetation, so reduction of emissions by the company does not necessarily mean low levels of fluoride in plant tissue. This is exemplified by the peak of 763 ppm F in 1970 conifer needles. Since the majority of trees in the Columbia Falls vicinity are conifers we must consider cumulative effects of continuous emissions. Note also that conifers serve as winter wildlife forage and are included in the 35 ppm state forage standard.

Data of the Air Quality Bureau is shown in Figure 4. Thirty-four conifer samples were collected in May of 1973 at sites ranging up to four miles from the Columbia Falls plant. These samples of needles from 1970 through 1973 illustrate the cumulative effects of fluoride emissions.

When this data is compiled and plotted on a graph the impact of gaseous and particulate fluoride on the area surrounding the plant is obvious. The Y axis of this graph represents distance from the Anaconda Aluminum plant while the X axis represents ppm fluoride. The X axis is also entered in logarithmic increments of 10, 100, 1000 ppm, to reduce the space on the graph necessary to plot the high readings occurring close to the plant. The number of violations per total samples is entered at each point on the graph. The states 35 ppm forage standard also has been entered.

The graph clearly shows that fluoride in vegetation exceeds the standard from the plant site to points more than 3 miles away. Peak readings of 763 ppm F at one mile and 180 ppm F at two miles from the plant illustrate the violations of the state fluoride in forage standard. These levels have caused a profusion of fluoride symptoms on vegetation surrounding the plant. The graphs do not present data in a specific direction from the plant but are means of all samples collected at a particular distance.

The state's findings agree with those of Carlson (38) who reported high levels of fluoride within four miles of the aluminum plant. Carlson, working for

SDHES CONIFER SAMPLES

Superscript indicates number violations/ total samples.

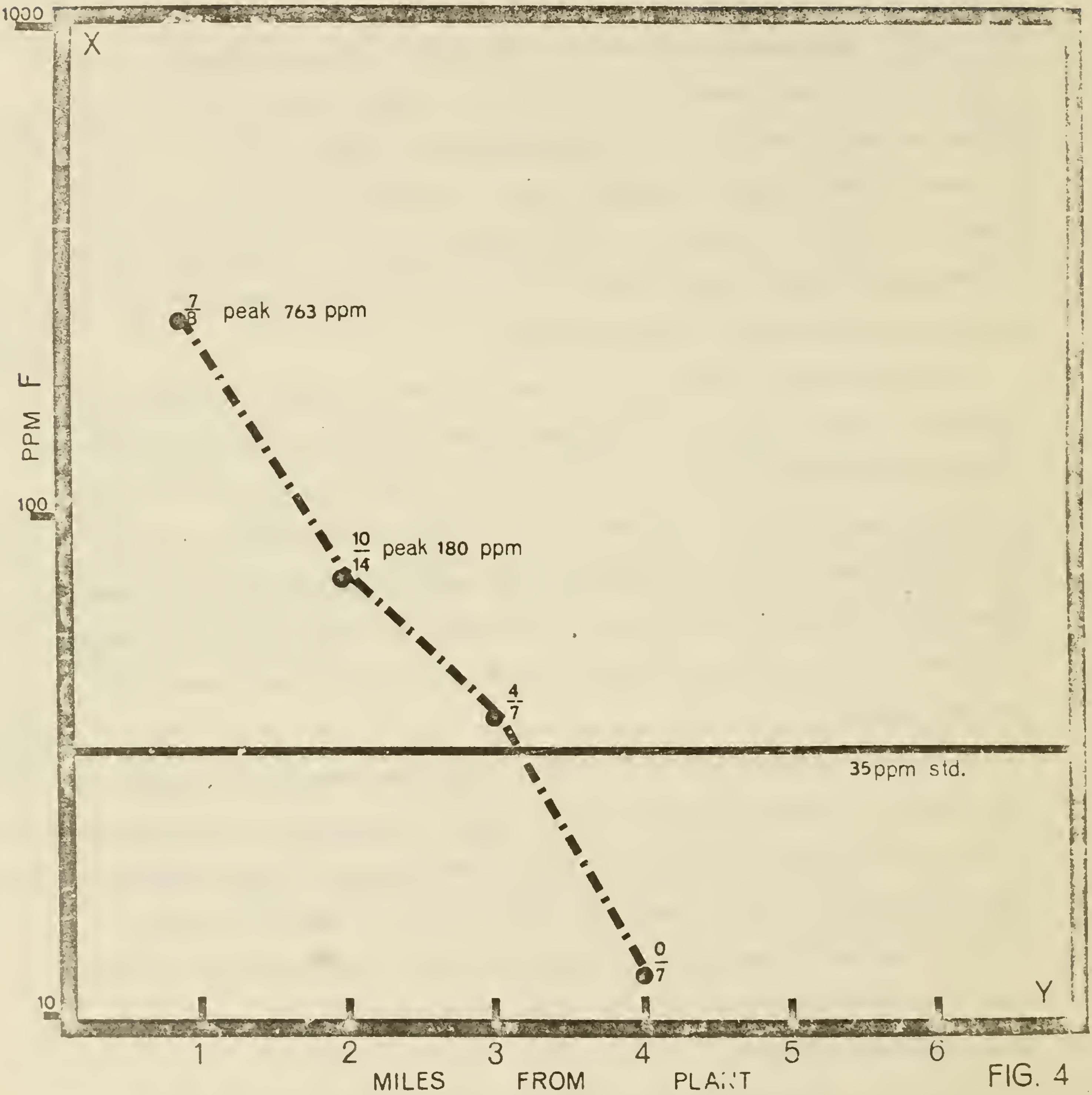


FIG. 4

the U.S. Forest Service, set up vegetation sampling plots on 10 radii extending up to eight miles from the plant. The samples were collected in June-July and October-November, 1970. The sample included grass, herbaceous plants, and conifers. The analytical work done on these vegetation samples included analyses of fluoride in tissue, and histological preparations of damaged cells. Results of this study indicate that levels of fluoride violating the standard existed up to four miles from the plant. Damage symptoms were evident on vegetation up to 8 miles from the plant.

Anaconda Aluminum reduced its fluoride emissions in 1970-71, and Carlson monitored the vegetation again in 1971 (39). A comparison of Figures 5 and 6 illustrates Carlson's findings. The average fluoride concentrations were determined. Lines (isopols) were drawn to encompass areas containing fluoride levels equal to or greater than the values indicated. Thus the 60 isopol includes plots with vegetation samples having fluoride levels equal to or greater than 60 ppm. Comparing the two figures it is apparent that a reduction in fluoride emissions did occur within the two year period of the study. However, excessive fluoride levels were still present within four miles of the plant.

In his 1971 study of fluoride in Glacier National Park, Gordon (29) reported that increasing accumulations of fluoride occurred in pine needles ranging from one to four years of age. Though the current year's needles of Ponderosa and Lodgepole pine trees did not exceed the 35 ppm fluoride level set by the state, the four year old needles did. Levels as high as 49.8 ppm were found in 1968 needles of Lodgepole pine from the Belton Hills zone of the park.

To date no survey of fluoride damage to crops or timber in the Flathead Valley has been made. The excessive amounts of fluoride may affect both yield and quality of crops adversely (40). Such studies have been conducted in other states and financial loss from fluoride has been documented (41). Certainly, the damage to forests in the vicinity of Columbia Falls constitutes a loss of valuable timber. Besides causing economic losses, these excessive levels of fluoride

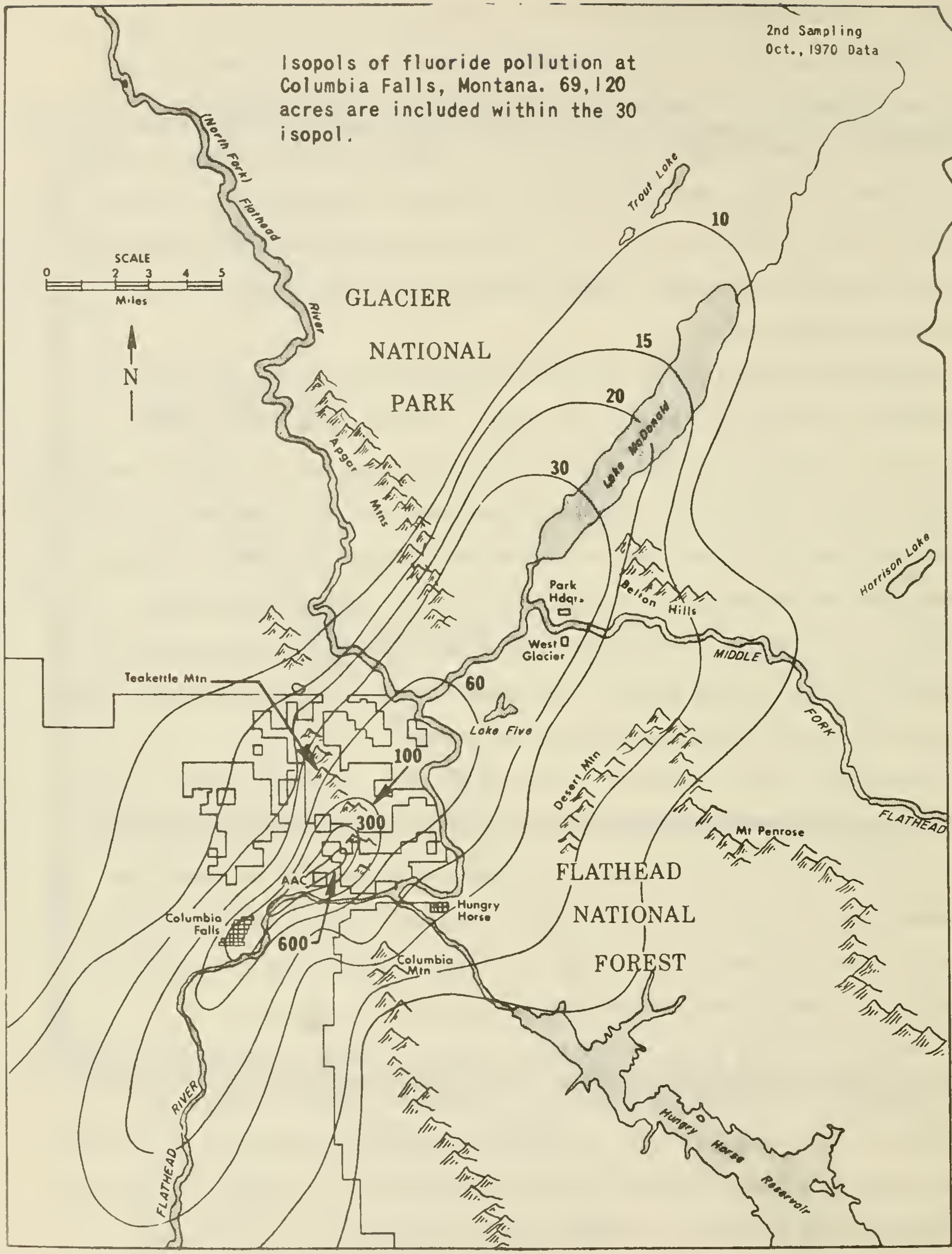

Isopols of fluoride pollution at Columbia Falls, Montana. 69,120 acres are included within the 30 isopol.
2nd Sampling
Oct., 1970 Data
SCALE
0
2
3
4
5
Miles
N
GLACIER
NATIONAL
PARK
(North Fork) Flathead River
Apgar Mtns
Trout Lake
Lake McDonald
Harrison Lake
10
15
20
30
60
100
300
600
Park Hdqrs
Belton Hills
West Glacier
MIDDLE FORK FLATHEAD
Teakettle Mtn
Lake Five
Desert Mtn
Mt Penrose
AAC
Columbia Falls
Hungry Horse
Columbia Mtn
FLATHEAD
NATIONAL
FOREST
FLATHEAD RIVER
Hungry Horse Reservoir

FIGURE 5

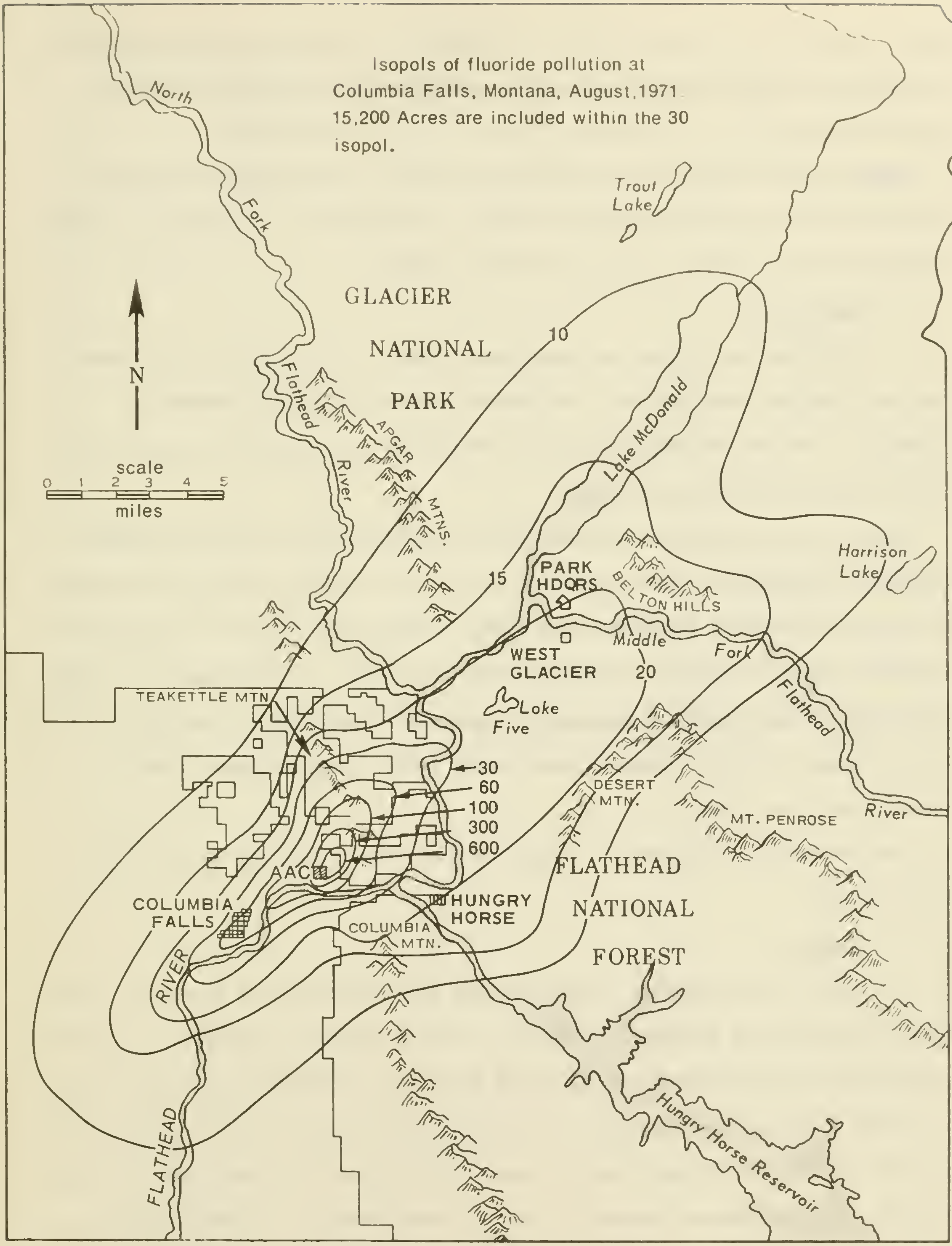

Isopols of fluoride pollution at Columbia Falls, Montana, August,1971
15,200 Acres are included within the 30 isopol.
North Fork
Flathead River
GLACIER NATIONAL PARK
APGAR MTNS.
Trout Lake
Lake McDonald
Harrison Lake
N
scale
0 1 2 3 4 5
miles
10
15
20
PARK HDQRS.
BELTON HILLS
Middle Fork Flathead River
WEST GLACIER
Lake Five
TEAKETTLE MTN.
30
60
100
300
600
DESERT MTN.
MT. PENROSE
AAC
COLUMBIA FALLS
HUNGRY HORSE
COLUMBIA MTN.
FLATHEAD NATIONAL FOREST
RIVER
FLATHEAD
Hungry Horse Reservoir

FIGURE 6

pose a hazard to the plant and wildlife communities of the upper Flathead Valley and Glacier National Park, perpetuating a persistent decline in the state of that environment.

Additional data describing the levels of fluorides in vegetation in Glacier National Park and around AAC are included in Appendicies C & D. The appendices include data from the Air Quality Bureau and from AAC.

I. Visibility

Fluorides per se have no significant effect on visibility except where they are found as particulates. Particulate matter has certain effects on visibility. In the Columbia Falls area, visibility is affected by Anaconda and other sources of particulate matter.

Some of the particulates emitted from the aluminum plant are hydrocarbons driven off the anodes. These hydrocarbons result in the blue haze seen issuing from the roof lines of the plant. At times, the haze can result in noticeable deterioration in visibility, especially near the plant. This phenomenon is most pronounced during periods of atmospheric stability (inversion). The effect is reinforced by other sources of particulate matter, such as tepee burners, boilers, and dusty roads.

The National Weather Service observes and records visibility at the airport. See Table 18.

J. Energy

Much of the following information has been obtained from Bonneville Power Administration as of October 1, 1973 (42). For the Pacific Northwest, firm load requirements for 20½ months are estimated to be about 200 billion kilowatt hours, or about 14,000 average megawatts. As of October 1, there existed a deficiency of about 14 billion kilowatt hours or about 7.4% of the firm requirements. This has been reduced somewhat because of the rain and snowfall; in addition the energy conservation measures in the Pacific Northwest have also reduced the demand.

Table 18

Days When Smoke Reduces Visibility in Flathead Valley to 6 Miles or Less

Data Taken at Glacier Park International Airport

	65	66	67	68	69	70	71	72	73	Total
Jan.	0	0	0	1	1	4	1	1	0	8
Feb.	3	4	0	NR	15	6	3	3	0	34
March	0	0	0	0	10	4	0	0	0	14
April	0	0	0	1	1	1	1	1	0	4
May	0	0	0	0	0	1	1	1	0	3
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	3	0	0	1	1	0	0	5
Sept.	0	0	0	7	1	6	0	0	0	14
Oct.	2	6	4	10	11	10	5	9	0	57
Nov.	3	2	5	5	8	8	2	7	0	40
Dec.	2	1	0	1	7	2	0	1		14
	10	13	12	25	54	43	14	22		

Interruptible power supplied to industry was curtailed on April 11, 1973 from 1140 megawatts to 520 megawatts, reduced again on July 20, 1973 to 260, then to 220 megawatts. Energy consumption by Anaconda Aluminum varies according to production. For 1972 consumption was 8,796,000 KWH daily; 268,265,000 KWH monthly, and for the whole year, 3,219,175,222 KWH. The daily figure is equivalent to an instantaneous value of 366.5 megawatts. According to the BPA, at full production full demand, Anaconda demands 372 megawatts of electric energy. THis is equivalent to 2 plants the size of the Montana Power's J. E. Corette Plant in Billings or about the same size as one of the steam electric generating units being installed in Colstrip, Montana. THis annual consumption is equivalent to 530,000 individual residential customers (Montana Power Company - 1971 average 6032 KWH/year).

K. Raw Materials

The basic raw materials for the process are alumina, cryolite, aluminum fluoride, carbon and electricity. Table 5 (Section II) lists all the materials involved and amounts used, with raw materials given in the first part of the table.

As a point of reference, Anaconda Aluminum is credited with having 3.78% of the U.S. aluminum production capacity in 1971 and 1.52% of total world production capacity (13). Percentage involvements in the use of other materials are correspondingly small. In the cases of raw materials, especially alumina and cryolite, both of which are used for more than aluminum production, AAC's influence on markets is even less significant.

L. Water Quality

The Flathead River is the major water course in the area which at Columbia Falls consists of the sum of the North, Middle, and South Forks of the Flathead River. Before entering Flathead Lake, the river is joined by flows from Whitefish Creek and the Stillwater River. The Flathead is part of the Pend Oreille River Basin. It has a drainage area of 4,464 square miles above Columbia Falls.

Average discharge at this point (43 years data) is 9,712 cubic feet per second (CFS) or 7,036,000 acre feet per year. Average for October, 1970 to September, 1971 is 9116 CFS. Flows have been adjusted for Hungry Horse Reservoir drawn-down. Minimum flows observed have been 798 CFS on December 8, 1929 and for the above period 1,550 CFS on November 4 and 5, 1970 (43).

The quality of the river at Columbia Falls is fairly good. Average fluoride content of the water is 0.3 ppm at Columbia Falls and 0.11 ppm at Bigfork (44). AAC disputes these USGS (44) figures and states that fluoride content of the Flathead River is 0.03 - 0.04 ppm. Average concentrations of naturally occurring fluoride in surface water ranges from 0.02 ppm to 0.1 ppm in the Northeastern U.S. to over 0.2 ppm in the midwestern and western states (28).

AAC neither withdrawn nor discharges water from the river at present. Plant water is supplied from wells located on company property and capable of producing 5600 GPM, compared to the river's 900,000 GPM at low flow. Well depths range from 60 to 175 feet and drawdown is from 2 to 16 feet at maximum production. The nature of the river bed and underlying alluvial gravels and depth of wells indicate that they are recharged by the river.

Plant cooling water is held in a seepage pond and scrubber water is treated and recirculated through the system, with makeup for evaporative losses. Scrubber water, circulating at a rate of 1530 GPM, has a pH of 3 and contains 1-4 ppm calcium as $CaCO_3$, 1.2-1.5 gm/liter fluorides as F and 100-130 ppm aluminum (1). Scrubber water is treated with lime to precipitate calcium fluoride. The water is clarified and the precipitated CaF_2 is dewatered and stored on the plant premises north and slightly west of the plant itself. The seepage pond south and slightly east of the plant, receives, to the department's knowledge, only cooling water and treated sewage.

M. Economics

CORPORATE

It would be beneficial and desirable to use as a decision-making factor the economic health of the Columbia Falls plant. Unfortunately, this information has not been made available and is retained as confidential by AAC. Therefore, we must rely on data from the industry as a whole and on the economic health of the Anaconda Company. Tables 19 and 20 present the corporate financial picture per Anaconda's 1973 annual report (45), and Moody's Industrial Manual, 1973, and manual supplements to April, 1974 (46).

Table 19

Financial Data

AAC Division	1973	1972	1971
Sales as % of the total Company Sales	20.5%	19.6%	16.3
Sales	$276,256,000	$198,434,000	$184,093,000
Anaconda Company			
Gross Revenues	1,343,088,000	1,011,600,000	946,500,000
Expenditures for a addition to plant and equipment	79,074,000	122,599,000	89,855,000
Assets in property, equip.,etc.	1,322,365,000	1,368,147,000	1,284,876,000
Retained Earnings	491,028,000	414,861,000	284,560,000
Net Income (loss)	88,053,000	133,037,000	(353,844,000)

The tables point out that after a couple of bad years, the corporation is now doing quite well. Earnings per share increased from $2.00 in 1972 to 3.16 before extraordinary items. Long-term debt is at its lowest in 6 years and revenues are approaching the 1969 level, even though copper production was less than 50% of 1969 levels (before expropriation of Chilean properties). Return on equity for 1973 was 6.75% (before extraordinary items); in 1972 it was 4.54%.

Forbes Magazine has reviewed the performance of the non-ferrous metals industry in recent years (47). The Anaconda Company did not fare too well by "yardsticks" of 5-year average performance--not surprising considering the uncompensated 17%

Table 20

Five-Year Financial and Operating Summary (45)

For the year ended Dec. 31 (millions of dollars):	1973	1972	1971	1970	1969
Sales & other operating revenue	1,343.1	1,011.6	946.5	977.4	1,410.6
Depreciation & depletion	45.6	44.1	46.9	44.2	49.9
Income (loss) before extraordinary items	69.7	44.1	(6.2)	72.3	102.3
Extraordinary gain (loss	18.3	88.9	(347.6)	(4.3)	
Net income (loss)	88.1	133.0	(353.8)	68.0	102.3
Dividends paid	11.0	2.7	10.9	41.6	48.2
Capital expenditures for plant & equipment.	79.1	122.6	89.9	90.5	127.0
At December 31 (millions of dollars):					
Working capital	261.4	291.0	266.0	291.9	261.6
Long-term debt (due after 1 year)	252.4	278.1	391.5	366.5	205.6
Shareholders' equity	1,048.1	971.4	840.8	1,205.6	1,179.2
Common shares outstanding	22,069.3	22,055.8	21,890.8	21,891.6	21,891.2
Per share of common stock:					
Income (loss) before extraordinary items	3.16	2.00	(.28)	3.30	4.67
Extraordinary gain (loss)	.83	4.03	(15.88)	(.20)	
Net income (loss	3.99	6.03	(16.16)	3.10	4.67
Dividends paid	.50	.125	.50	1.90	2.20
Shareholders' equity	47.49	44.04	38.41	55.07	53.87

reduction of their assets. The last year was an improvement for Anaconda. Although it was below the industry median for all indicators, Anaconda's profitability has been as follows in Table 21.

Table 21

Profitability

	Return on Equity		Return on Total Capital		Sales		Earnings per Share	
	5 yr.	1 yr.	5 yr.	1 yr.	5 yr.	1 yr.	5 yr.	1 yr.
Anaconda	def.	5.9%	0.1%	5.0%	1.3%	24.7%	P-D*	D-P*
Median	11.8%	12.0%	8.7%	9.3%	9.1%	28.1%	2.1%	29.0%

*Profit to deficit or deficit to profit

The data are based on the last quarter of 1972 and the first three quarters of 1973.

In general, recent history indicates that while the Anaconda Company had a couple of bad years largely because of Chilean government action, it is recovering well. According to the industry and financial analysts, profits and earnings were lower than expected for several reasons, the largest of which was wage and price controls.

The price of aluminum ingot, for example, was held by the Cost of Living Council (COLC) Phase IV controls at 25¢/pound for 1973 and 29¢/pound early in 1974. When aluminum was decontrolled March 20, 1974, the price was 29¢. As of April 29, 1974, one month after deregulation, the ingot price was 31½¢ per pound (48).

Perhaps more relevant to the considerations are forecasts for 1974 and beyond. Forbes (47) quoting the U.S. Bureau of Mines, says that the price of aluminum is forecast to rise 29% over 1971 levels (29¢/pound) by 2001, based largely on resources availability. The Engineering and Mining Journal staff (49) reports that for 1974 the market outlook for aluminum is good, production should be up largely due to increasing hydro power in the Pacific Northwest, and producers reported strong demand for the first quarter of 1974. The same magazine carried a report by the director of economic affaris for Reynolds Metal Irving Lipkowitz (50) on the economic picture of 1973 and forecasts of 1974. Lipkowitz says:

> "Taken all in all, 1973 was undoubtedly a better period than the industry has experienced since early 1970. But the improvement in demand last year was attended by a complex combination of pluses and minuses in the supply area. Prices and profits also improved, but Phase IV price restrictions prevented recovery to satisfatory levels."

In later discussion on prices we find data from Metals Week presented as follows:

Table 22

Primary Aluminum Ingot Prices
(METALS WEEK monthly averages; ¢ per lb)

1973	Major U.S. Producers	Price	"U.S. Market" METALS WEEK Discount from (-) Premimum over (+) Producer Price
January	25.0¢	20.5¢	-4.5¢
February	25.0	20.9	-4.1
March	25.0	22.7	-2.3
April	25.0	23.8	-1.2
May	25.0	25.0	0
June	25.0	25.0	0
July	25.0	25.0	0
August	25.0	25.0	0
September	25.0	28.9	+3.9
October	25.0	30.8	+5.8
November	25.0	33.8	+8.8
December	25.0	35.5	+10.5

The major U.S. producers are those subject to COLC controls at the time. The "U.S. Market" prices in Table 22, based on Metal Week data from "various sellers and buyers of primary aluminum ingot" reflect prices of "metals dealers and import transactions not subject to Phase IV controls." Mr. Lipkowitz said further, "although a smaller share of the tonnage sold moves at the composite 'U.S. market' price, that price does provide some indication of what the domestic industry-wide price would have been without Phase IV restrictions." THe negative values in the table are a result of prior commitments of production. The data and forecasts seem to indicate a strong trend toward increased prices and profitability in aluminum.

Lipkowitz's predictions for 1974 could be characterized as cautiously optimistic with certain constraints relative to the energy crisis and its effects on the general economy. Increased production, price "recovery", strong markets, all spell glad tidings for the industry as a whole. Anaconda's financial status is further boosted by its copper production and the rosier predictions for that industry.

Forbes (47) had the following to say about the metals industry in general:

> "Everybody was grousing. Price controls were disrupting their markets, restricting their profits, destroying their ability to undertake the exploration and expansion programs needed to support their future development. But for all that, in 1973, most metalsmen found it difficult to contain their jubilation. A year that started out as just so-so wound up as the biggest, if not necessarily the best, in the metals industry's history.
>
> "What about 1974? If the energy shortage doesn't disrupt the economy, most metals producers should have another good year, with bigger spending for capital goods offsetting any drop in consumer spending. Dead on its feet a year ago, the aluminum industry at year's end was running as close to capacity as its inadequate power resources would let it. So was the copper industry and lead and zinc."
>
> "Aluminum's Big Three (Alcoa, Reynolds and Kaiser), only moderately profitable at best in 1972, moved solidly back into the black, with Reynolds' and Kaiser's earnings rising in quantum jumps. The copper producers, who had been less exposed in 1972, posted hefty, if more moderate, gains of their own."

LOCAL AND STATE

The Columbia Falls plant is a major influence on the local economy, although the plant's effects on the economy of the state are considerably less. A recent report by the State Department of Intergovernmental Relations (IGR) (51) analyzed AAC's contribution to the county and found not surprisingly that the economy of Flathead County would suffer if the aluminum plant's economic contribution were removed. The following Table 23 compares AAC's annual contribution to the appropriate county and state figures.

Table 23

	State	County	AAC
Direct Wages	$2,100,000,000	$107,701,010	$9,500,000
No. of Employees	283,000	15,560	911
Property Taxes	219,101,201	9,195,027	1,349,419

As a further indicator of Anaconda's influence personal income increased in Flathead County by 13.8%, in 1967-68 when the plant expanded. Contract construction earnings grew by 11.8% in the same period. The following year after construction, personal income grew less than 1% and contract construction earnings declined by 12.3%. In Flathead County, manufacturing provides about 31% of county earnings, of which 52.7% is derived from the wood products industry and 33.4% from the aluminum industry. Over the report (51) study period 1967-71, total employment grew by 3.2% compared to 4.2% statewide.

The Anaconda Company paid a total income tax of $5.5 million on all its operations in 1972, amounting to 0.54% of its gross revenue (46).

V. POSSIBLE ACTIONS BY THE DEPARTMENT

The only alternatives available are granting or denying the variance request. The State Board of Health and Environmental Sciences has statutory authority to allow variances only if present emissions are no danger to the public health and present no hazard to the public safety and, further, if the control of these emissions would produce more hardship than benefit to the public. The actions available to the department of health are in the form of a recommendation to the board as to the disposition of the variance request. A denial of the variance implies that the department should enforce the applicable regulation. The AAC plant's emissions are clearly in violation of the regulations.

VI. IMPACTS OF POSSIBLE ACTIONS

A. Granting Requested Variance

Any analysis of the impacts of granting the variance as Anaconda Aluminum has requested would be hypothetical as no definite plan for emission control has been proposed. What is proposed is a study program, with hardly any commitments to emission control. Apparently a significant factor is whether the secret process will be saleable. No provisions have been made for alternate strategies. Thus, there is no assurance that any emission reductions would occur. Assuming present company operating practice, it is reasonable to project that emissions will not increase over existing levels.

Given the above conditions, impacts can best be summarized very succinctly: little change in current situations and trends. The net result would be an insignificant change in emissions and a continuation of present trends and situations. Cumulative effects of such continuing pollution would produce far more hardship to the public than benefit, if any.

If the petitioner could treat all its emissions from the plant with the "Foamator" process, compliance with the existing regulations would be achieved. The effect would be nearly the same as if action were taken by the state to achieve compliance with the existing regulations. The only difference would be in the time required to achieve such compliance.

AIR QUALITY, VISIBILITY, HUMAN HEALTH

The population would continue to be subjected to potentially hazardous carcinogenic agents, high levels of short-term suspended particulate, and the accumulation of fluorides. A continuing air pollution control program by the state is expected to reduce suspended particulate levels and lessen visibility reduction caused by air pollution, but Anaconda Aluminum would remain an unmitigated major contributor.

VEGETATION

One of the most certain effects of continued plant emissions would be the continued accumulation of fluorides in vegetation and a continuation of damages in Glacier National Park and areas surrounding the plant.

Anaconda Aluminum's present emission level is likely to cause an eventual change in the types and numbers of plants growing in the area. Continued fluoride emissions would be expected to eliminate certain sensitive plants from the forest community. Resistant members of the plant community could replace the sensitive plants. For example, junipers growing in stands along with more sensitive Ponderosa pine and larch would be expected to increase in numbers. The same might occur with resistant strains replacing intermediately sensitive aspens along stream banks in the area (29). Changes in plant communities in the area should not be treated lightly; as one must consider that the stable plant community which existed prior to operation of the aluminum plant took thousands of years to develop.

ANIMALS

The accumulation of fluorides in the vegetation creates the possibility that animals may build up damaging concentrations, as is now occurring. The magnitude of the potential ecological effects is unknown.

ECONOMICS

The economic situation would be unchanged if the variance were granted, and would continue to depend largely on other factors such as the energy crisis, the state of the economy, and the price of aluminum. Social factors also would be largely unaffected by granting the variance.

ENERGY

Granting the variance as requested would have no direct effect on energy consumption. THe current power situation may affect the aluminum plant adversely because of the nature of Anaconda Aluminum's power contract with BPA. Within certain limitations BPA can reduce electricity supplied to Anaconda Aluminum should the need arise. In fact, Anaconda Aluminum was curtailed by the amount of interruptible power for portions of 1973. Power has been restored and AAC is now at full production or nearly so. At full production Anaconda Aluminum has a demand of 372,000 KW with 88,000-90,000 KW of interruptible and 284,000 KW of modified firm power. According to Anaconda Aluminum the 1972 total average demand was about 376,000 KW with 11,500 KW of that being used for non-production purposes.

WATER QUALITY

Adverse impacts on the quality of the water are not expected. Predictive techniques for assessing air emissions and resultant quality of water are essentially non-existent. No significant effects have been observed.

No effects should be seen on the consumption or disposition on process raw materials or natural resources other than those discussed.

B. Denying the Variance

If the variance were denied the plant would remain in violation of the regulations. But Anaconda Aluminum would no longer be subject to the stay of enforcement granted by the state during the duration of the variance proceedings.

1. Compliance with the regulations

There is no action by the state which could result in immediate compliance by AAC, as a time lag would exist for construction of a control system. Reasonable enforcement of current regulations at the minimum would require (1) a firm commitment from AAC for control of all emissions; (2) a specific program with provisions for alternative methods to achieve such control; and (3) a specific time schedule to achieve compliance. Such requirements would make note that there is technology available to control emissions, but would not prescribe or proscribe any promising control systems.

AIR QUALITY, VISIBILITY, HUMAN HEALTH, VEGETATION

The probable impacts fo variance denial would be an improvement in air quality, reduction of vegetation damage and accumulation of fluorides in the area vegetation, reduction of actual hazards to animals and possible hazards from suspended particulate and carcinogens, improved visibility in the area, and minimal economic disruption to the area. In fact, economic benefits might occur due to the increased manpower that would be required. In regard to air quality control, a proposed standard of 9.4 lbs of particulate matter/ton of aluminum would necessitate approximately a 48% reduction of particulate emissions. This would reduce total particulate emissions from a maximum of 9,000 lbs/day to 4,700 lbs/day or from a maximum of 18 to 9.4 lbs/ton. Fluoride emissions would be reduced to 864 lbs/day or approximately 1.73 lbs/fluoride/ton of aluminum produced (TAP). These figures are at full production. Some damage to vegetation might still occur even with the reductions but there most probably would be an elimination of further accumulations in Glacier National Park.

ENERGY

Some additional energy would be consumed for operation of the secondary air pollution control system. Literature data indicate that from 230-455 KWH per ton of aluminum are consumed by the secondary systems. Estimates are difficult to prepare due to variations in design, climate, control efficiency and other tors, but they do provide some indiation. At Anaconda Aluminum this would amount to between 41 to 82 million KWH per year or an increase of 1.2 to 2.5% of AAC's full production in annual use. Such an increase in electrical demand for these low power air pollution control systems would be far outweighed by the significant reduction in the emission of air pollutants, especially the fluorides and polynuclear aromatic hydrocarbons.

WATER QUALITY & HYDROLOGY

Direct impacts on stream quality are not expected as a result of any action the board might take. Water quality standards and proposed effluent discharge standards would prevent significant quantities of any pollutant from being discharged to the stream. Moreover, the state has a stream "non-degradation law" which prevents a discharge which causes any measurable increase in contaminant concentrations. As previously mentioned, Anaconda Aluminum has no direct discharge, but in all probability seepage from the ponds goes directly to the rivers. No changes are forecast in this method as the state water quality engineers consider the treatment quite good. The toxicity of AAC's Foamator foaming agent is unknown. Before AAC could utilize such a system, water hazards would have to be studied. If such hazards were found to make the "Foamator" process intolerable, then AAC would have to employ some other existing control technology. Hydrological impacts of any proposed action also are expected to be insignificant. Maximum production from the wells could conceivably reduce total stream flow by a maximum of 0.62% if no water was returned. This is an extreme case and is not probable. Anaconda Aluminum should achieve a closed system for scrubber water or 100% recirculation of process waters. This in practice in not achievable as some will be lost by evaporation at the scrubbers and possibly some at the treatment facility. Evaporation losses from the secondary scrubbers should be low, as inlet gases are fairly cool, about 30°F above ambient temperature.

2. Plant Closure

Benefits to be obtained by closure of the plant would be significant in terms of emission reduction and the corresponding reduction of pollutant levels in the ambient air. This would result in a cessation of the accumulation of fluorides in vegetation and would elimiate the hazards of adverse effects to animals and man. Glacier Park would no longer experience the damage caused by fluoride levels. Increases in visibility could be expected and large amounts of electrical energy would be released for other uses. Assigning dollar values to such benefits is highly subjective. Currently there are damage suits filed against Anaconda Aluminum demanding payments of approximately 3.5 million dollars. Recent Forest Service studies have shown that timber losses due to fluoride damage are substantial but no specific values have been determined (52). There are, however, preliminary indications of hundreds of millions of dollars. Hundreds of thousands of acres of USFS lands have shown elevated fluoride levels, and tens of thousands of acres show visible vegetation damage, not to mention lack of growth.

The most severe and probably the most obvious adverse consequences of closing the plant would be the economic impact on the immediate area. Loss of payroll, tax payments, increases in unemployment and welfare and decline in the auxiliary services required would be expected. The dollar values of these effects are subject to numerous variables but obviously would be considerably more severe in the immediate area than the whole state. Effects on the world or U.S. production of aluminum metal should not be significant. The AAC petition describes a payroll for the plant at approximately $9.5 million per year. An IGR report (52) puts total earnings for the state of Montana for 1973 at about $2.1 billion, with about 283,000 employees. Property tax payments on the Columbia Falls plant are about 1.38 million dollars or 14.4% of the property tax revenue of Flathead County. AAC's contribution to total state revenues, however, is considerably smaller. Thus the magnitude of the adverse effects would be significantly mitigated.

VII. ANALYSIS OF DEPARTMENT'S PROPOSED ACTION

Based on the information previously presented, and the criteria for decision making, it is the department's position that the interests of the state would best be served by denying the variance request. Theneed to control emissions from the plant has been clearly established. THe emissions from the plant, fluoride and particulate, have extensively damaged vegetation and continue to do so. THere is a real potential of subjecting people and wildlife to the risk of adverse effects associated with the air pollutants.

The guiding precept of public health work has been and will continue to be to err on the side of protecting the public environment until it can be affirmatively demonstrated that such protection is unnecessary. Indeed, the Clean Air Act of Montana declares as policy the achievement of air quality that will protect human health and safety and to the extent possible "prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state and facilitate the enjoyment of the natural attractions of the state." When data are lacking or inconclusive, prudence dictates that exposure be minimized until it is proven that higher levels of exposure can be safely tolerated. Any question as to the severity of the hazards to the public should not be resolved at public peril.

Consistent with these policies, the air pollution control program in the State of Montana has promoted and should continue to encourage and, in many cases, require the use of the most advanced technology available for the control of air pollutants. The existing fluoride regulation and the proposed particulate regulation clarifications are consistent with these policies. Existing technology appears efficient enough to achieve compliance with the regulations.

AAC in essence has requested that the state share the risk of research for emission control with no promise of compliance ever. There are means available to achieve compliance without risk.

Existing technology permits the installation of pollution control systems at AAC for cost commensurate with what other aluminum companies have (voluntarily and involuntarily) expended on no greater investment base than AAC's.

The state does not say that any given air pollution control system could be taken "off the shelf" and installed at AAC to achieve immediate compliance. Indeed process and equipment modification probably will be necessary. The data indicate that some systems now can achieve compliance with standards on direct application.

Plant closure in the department's opinion is a remote possibility. Experience with other industrial pollution sources including aluminum companies compels the conclusion that plant closure is dictated by corporate economics, not by pollution control. In support of this belief, Anaconda's 1973 annual report states: "The (aluminum) division achieved record sales during 1973 but operated at a loss due to the power shortage in the Pacific Northwest, alumina production problems in Jamaica and prices that were held below free market levels by government control." The Anaconda Company did not shutdown the Aluminum Division.

The environmental impacts of granting the AAC request removes it from consideration as a viable an option.

Denying the variance is far more desirable course, for the probable adverse environmental effects are minimal. Denial of the request would put the plant in violation of the fluoride regulations, release the parties from the stay of enforcement and perhaps necessitate actionby the department to abate the unlawful emission. THis action is likely to result in abatement of the emission through application of existing emission control technology and would achieve compliance at what appears to be a reasonable cost.

The department is obligated to consider the effects of its action on the whole state. The comments received from the public indicate that the conclusion expressed in the draft statement appropriately reflected the public interest.

The department proposes that compliance with fluoride restrictions be achieved at the least in accordance with a schedule corresponding to that presented in the proposed amendments to the aluminum plant regulation. Fluoride emission restrications can be so achieved in accordance with this department's proposal, by a good faith undertaking for compliance by AAC. Generally the following schedule should be applied for such compliance:

1) Not later than July 31, 1974--Submit to the administrator a final control plan which describes, at a minimum, steps which will be taken to achieve compliance.

2) Not later than December 31, 1974--Conclude negotiations for and execute all necessary contracts for emission control systems or process modifications in compliance with final control plan.

3) Not later than March 31, 1974--Initiate on-site construction or installation of emission control systems or process modifications.

4) Not later than May 31, 1976--Complete on-site construction and installation of emission control systems and process modifications.

5) Not later than July 31, 1976--Achieve compliance and certify such compliance to the administrator.

6) Within five days after the deadline for completing increments (ii through v), certify that each increment was met.

Copies of all present and proposed regulations are appendixed in A.

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All comments will be retained in the offices of the Air Quality Bureau for a reasonable period of time and will be available for public inspection during working hours.

The background of persons contributing to The Anaconda Aluminum Company variance impact statement are as follows:

Donald Holtz, Chief, Air Quality Bureau, B.S., Mechanical Engineering, Montana State University, 1960, registered professional engineer, Montana, nine years experience in air pollution control.

Carl Ripaldi, B.S., Botany, University of Massachusetts, 1968, M.S., Plant Pathology, Rutgers University, 1973, research on the effects of air pollutants on vegetation, seven months experience as an Air Pollution Control Specialist in Vegetation for the Air Quality Bureau.

Daniel Vichorek, B.A., Journalism, University of Montana, 1969, experience as a general assignment and police reporter for the Billings (Montana) Gazette and the City News Bureau of Chicago, 16 months experience as a technical writer for the Environmental Sciences Division.

David Nunnallee, B.S., Civil Engineering, 1966, University of Washington; M.S., Sanitary Engineering, 1968, University of Washington; 2 years of research with University of Washington in Industrial Waste and Water Quality Planning; 2 years with the Department of Ecology in Washington as an engineer in water pollution; 3 years in the Water Quality Regional Office in Kalispell.

Dennis Haddow, B.S. in Biology, Eastern Montana College, 1971; approximately 3 years experience as an Air Pollution Control Specialist with the State Department of Health and Environmental Sciences, Air Quality Bureau Regional Office in Kalispell.

Jon Bolstad, B.S., Chemical Engineering, 1971, Montana State University, approximately 3 years experience in air pollution control with the Air Quality Bureau.

APPENDIX A
VARIANCE PETITION, RULES

PETITION FOR VARIANCE
FROM CERTAIN RULES AND REGULATIONS
TO
THE DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
AND
THE MONTANA STATE BOARD
OF HEALTH
BY
ANACONDA ALUMINUM COMPANY DIVISION
OF
THE ANACONDA COMPANY

Introduction

The Anaconda Aluminum Company Division of The Anaconda Company ("Anaconda Aluminum") hereby petitions the Montana State Board of Health to grant Anaconda Aluminum's reduction plant located at Columbia Falls, Montana, a one-year exemption under Section 69-3916 of the Revised Codes of Montana from compliance with the fluoride and particulate regulation set forth in §16-2.14(1)-S14080 of the Montana Administrative Code, and from §§16.2.14(1)-S1430 and S1460 to the extent they may be applicable directly or indirectly. During the one year period Anaconda Aluminum proposes to continue its efforts to develop technically and economically feasible solutions to further control its emissions from the Columbia Falls aluminum reduction plant, including in particular the purchase and installation of a foam scrubbing equipment pilot unit. If pilot tests prove technically and economically satisfactory such equipment will be installed on

sixty feet of one roof line and, again assuming successful operation, additional units would be installed toward achievement of Montana's emission standard.

In short, Anaconda Aluminum is seeking additional time in order to develop technology which will meet Montana's air pollution control regulations. However, in doing so, Anaconda Aluminum emphasizes that no aluminum company in the world has yet developed a technology for vertical stud Soderberg aluminum reduction plants which will meet Montana's fluoride and particulate regulation for aluminum reduction plants. Anaconda Aluminum can give the Board no absolute assurance that it will be able to do so.

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I. INFORMATION REQUIRED FOR VARIANCE REQUESTS.

II. DESCRIPTION OF OPERATIONS.

III. APPLICABLE MONTANA AIR POLLUTION CONTROL REGULATIONS.

IV. HISTORY OF AIR POLLUTION CONTROL PROGRAM AND EQUIPMENT.

V. PROPOSED ADDITIONAL AIR POLLUTION CONTROL EFFORTS.

VI. NO HARM TO PUBLIC HEALTH OR SAFETY WILL RESULT FROM GRANTING THE VARIANCE.

VII. ADVANTAGES AND DISADVANTAGES RESULTING FROM GRANTING OR DENYING THE VARIANCE.

I. INFORMATION REQUIRED FOR VARIANCE REQUESTS

The information required by the guidelines for requesting a variance is as follows:

A. The company's name, address and telephone number are:

The Anaconda Aluminum Company Division
of The Anaconda Company
1251 South Fourth Street
Louisville, Kentucky 40203
Telephone No. (502) 634-1511

The person authorized to receive service of notice at this address is Krest Cyr, Esq., Vice President and Counsel.

We would also like to request that notices be sent to:

Mr. E. O. Woster, Plant Manager
The Anaconda Aluminum Company
Columbia Falls, Montana

and

Robert T. Connery, Esq.
500 Equitable Building
730 - 17th Street
Denver, Colorado 80202

B. Petitioner is a Montana corporation and the names and addresses of its principal officers are as follows:

Name	Title and Address
John D. M. Place	Chairman of the Board, President and Chief Executive Officer 25 Broadway New York, New York 10004
Joseph B. Woodlief	Vice President 1251 South Fourth Street Louisville, Kentucky 40203
Krest Cyr, Esq.	Vice President and Counsel Aluminum Division 1251 South Fourth Street Louisville, Kentucky 40203
E. O. Woster	Plant Manager Columbia Falls, Montana

C. Petitioner's business or activity involved in this application is its aluminum reduction works located near the town of Columbia Falls, Montana.

D. The description of the process carried on at the plant is contained in paragraph II below.

E. The regulation involved in this application is Montana Administrative Code §16-2.14(1)-S14080 of the Department of Health and Environmental Sciences, and, to the extent they may be applicable indirectly and directly, regulations 16-2.14(1)-S1430 and 16-2.14(1)-S1460 of the Department of Health and Environmental Sciences.

F. The facts which show why compliance with the regulations would not be reasonable are discussed below under paragraphs IV, V, VI and VII.

G. The damage or harm which result to petitioner from compliance with the regulations are discussed below under paragraph VI.

H. Petitioner could presently meet an emission requirement of 2,500 pounds per day of fluorides in gaseous and particulate form from its Columbia Falls plant as a whole.

I. The advantages and disadvantages to the residents of the state resulting from requiring compliance or resulting from granting the variance are discussed below under paragraph VII.

J. Petitioner's operations do not constitute a nuisance.

K. Several individual damage actions are currently pending against the petitioner's Columbia Falls plant, primarily for trespass. These claims aggregate approximately $3.5 million for compensatory and penalty damages.

L. The modifications made to the thirty scrubbers described in paragraph III below are covered by a permit to operate issued by the Board. The other equipment and processes at the plant are not subject to the Board's regulations requiring permits to construct or operate since they were installed prior to the adoption of the Board's regulations.

II. DESCRIPTION OF OPERATIONS.

The Columbia Falls plant of Anaconda Aluminum is engaged in the reduction of alumina to aluminum by the electrolytic smelting process. The plant consists of 600 electrolytic cells or "pots." There are 120 pots in each pot line, which consists of two rows of 60 pots each under a roof approximately 1,100 feet long. There are 10 pot rooms at the Columbia Falls plant with a total roof line of approximately 2 miles and 220,000 square feet of roof line ventilation for the emissions of the process. Electricity is the primary energy source for the plant and 100,000 amperes are fed through each pot in the electrolysis of alumina to aluminum. In addition to the pots, there is a plant for making carbon paste, a casting plant, and the usual auxiliary services including a laboratory, warehouse, machine shop, electrical substation, and administrative offices. The plant has a capacity of 180,000 tons of aluminum per year.

The basic unit of production is the vertical stud Soderberg electrolytic reduction cell. The cell consists of an anode, cathode, molten electrolyte, molten aluminum, electrical bus system and gas collection equipment. The anode consists of a steel shell which holds the anode paste mixture. The anode carbon paste is a mixture of coal tar pitch and coke which is prepared in the paste plant under specified conditions. The cathode is a steel shell which is lined with brick, alumina, prebaked carbon blacks and cathode paste. The electrolyte or bath is molten cryolite and aluminum fluoride.

The electrolysis of alumina into aluminum produces fluoride and particulate matter. At the Columbia Falls plant at present gas and particulate matter are captured from the pot to the maximum extent technologically possible and vented through a gas burner and scrubber system which operates to remove approximately 98.5%-99% of the fluoride gas and particulate matter. The fluoride gas and particulate matter which are not captured by the venting system are drawn by natural draft through the roof ventilation system.

The molten aluminum in the pot resulting from electrolysis is drawn from the pot at regular intervals by the use of mobile vacuum crucibles, and transported to the casting plant where it is placed in one of the eight holding furnaces. These furnaces are gas fired with a back up of propane in case of emergency. The molten aluminum is then cast from the holding furnaces into water cooled molds of various sizes and shapes depending upon the product desired.

III. APPLICABLE MONTANA AIR POLLUTION CONTROL REGULATIONS.

The emissions from aluminum plants are specifically regulated by Regulation 90-019 (Montana Administrative Code, §16-2.14(1)-S14080) which provides that fluoride shall not be emitted in excess of 0.060 pounds per hour per reduction cell commonly called a "pot". As applied to the Columbia Falls plant this regulation results in an emission limitation of 864 pounds of fluoride per day. The regulation also provides that all particulate matter including particulate fluoride emitted from all of the pot rooms combined shall not exceed that allowed under MAC 16-2.14(1)-S1400 (the so-called "process weight" standard) or MAC 16-2.14(1)-S1460 (the Ringlemann No. 2 standard). Depending upon whether the "process" or operation under the process weight regulation is interpreted to be each pot or all pot rooms combined, the regulation may call for a limitation of between 1,188 pounds per day and 16,128 pounds per day.

IV. HISTORY OF AIR POLLUTION CONTROL PROGRAM AND EQUIPMENT.

An active air pollution control program has existed from the beginning of the plant's design and operation in 1955. Anaconda technical personnel studied various types of aluminum reduction plants in the United States, Canada, and Europe and concluded that the vertical stud Soderberg ("VSS") cell would provide the use of the best available technology at that time for the production of aluminum and for the collection and treatment of off gases.

When the plant commenced operation in 1955 all pots were equipped with skirts for capturing the gases. In addition, ducts, fans and multiclones were installed for removing particulates and fluorides. Thirty scrubbers were installed for removing fluorides. The hydrofluoric acid resulting from the scrubbing was neutralized by lime. No industrial water effluent has ever been or is discharged from the plant into any stream. The cost of the air pollution control equipment for fluorides and particulates in the 10 pot rooms initially was $5,960,032. An additional $1 million has been spent for testing and research relating to air pollution control efforts. $125,000 has been spent on equipment for testing and monitoring. Maintenance efforts related to air pollution control currently run approximately $1 million per year. The control level achieved with all of these air pollution control efforts and expenditures by 1969 was an emission of approximately 7,500 pounds per day from the plant of fluorides in gaseous and particulate form.

In 1969, Anaconda Aluminum undertook an intensive, thorough and exhaustive study of the collection and treatment system to improve to the maximum extent technically possible the control of its emissions of fluoride and particulates. At a cost of over $1 million the company has succeeded in reducing its emissions from the 1969 level of 7,500 pounds per day to a level of 2,500 pounds per day average at the current date.

To indicate the scope and depth of the studies which have been undertaken and completed they will be described in some detail. The following indicate the major elements of the company's research and development program on air pollution control systems during the period from 1969 through 1973.

A. Duct System - An engineering firm was retained to inspect, check and recommend changes to improve gas flow by reducing the pressure drop. The entire system was checked for flow rate, velocity, pressure drop and grain loading. Isokinetic sampling methods were used to assure the best results from the program. It was concluded that the duct system from the cells to the scurbbers were adequate for the flow-rate and velocities used.

B. Increased Flow Rate and Velocity - A test was initiated to double the volume of gas of 600 C.F.M. collected at each cell. If successful, the volume could further be increased to reduce potline roof emissions. This test continued for six months. Based on pot operating conditions and the amounts of fluoride collected, it was determined that a cell could not be efficiently operated without large burn-off at any volume greater than 600 C.F.M.

C. Consultants - American Air Filter Corporation, Ducon Corporation, Pulverized Machinery and others were brought to the plant to make recommendations for roof line corrections, improvements in gas collection at the cell and improved treatment at the scrubbers. Suggestions were made for improvements in the scrubber system but no one made any reasonable and workable suggestion for improving collection at the cell or at the roof monitors.

D. Cell Gas Burner for Burning Carbon Monoxide and Tars - A new design was developed and tested on several cells to improve the burner so it would burn continuously and more effectively. Tests indicated little or no improvement could be made to the existing burner.

E. Scrubber Improvement Tests - Tests were made to determine if the standby fan in each scrubber could be used to increase the available pressure drop in order to use a more efficient type of scrubber. Tests were successful. This provided the opportunity for a scrubber development program with promise to reduce the fluoride and particulate output of each of the scrubbers.

Two pilot units were installed, one from Ducon Corporation and the second from American Air Filter. Both were venturi type units. They were tested on gases from the cells. Input and output loadings as well as efficiency were studied using various gas to water ratios.

A horizontal venturi of commercial size was tested at one scrubber location. This unit did not achieve the efficiency required and was discontinued.

Preliminary results indicated that a vertical venturi scrubber after the multiclone with a packed (polypropylene saddles) section three to four feet in height in the scrubber tower warranted a full scale test. Such test was successful and a second unit was ordered. The two units were tested for several months and the results were favorable. Twenty-eight were ordered and installed in April, 1971 at a cost of $577,756. The efficiency of removal of fluorides improved from 89% to 99%.

F. Improvements in Operating Techniques - During the testing of the pilot units, a careful review of operating practices was initiated. Improvements were made in ore seals at the cells as well as to the method of treating open crust area resulting from "sick cells". To assure a continuation of good operating practices, meetings are being held each month with operating personnel to review and correct deficiencies that may arise.

G. Scrubber and Duct Cleaning - Crews are used to clean the duct system which plugs periodically as a result of "pot blows" and changing gas temperature. The number of crews was increased from one crew for the entire plant to a crew for each potline. Improvements in operation of the system were noted almost immediately. The number of employees used to maintain the duct and scrubber system was increased to 15, exclusive of daily skirt changing and other types of maintenance.

H. Wrapping of the Gooseneck Section - With the improved operation of the duct system as a result of additional maintenance, it was observed that the gooseneck section continued to leak gas under some conditions. In 1970, all the gooseneck sections were wrapped with asbestos cloth, preventing the gas leaks. The cost of this wrapping was $35,600.

I. Reduction of Fluoride Emissions - By the summer of 1970, the Company had achieved a 33-1/3% reduction of fluoride emissions, from 7,500 pounds per day to 5,000 pounds per day.

It was then that the venturi scrubbers were installed and the fluoride emitted from the plant was further reduced from 5,000 pounds per day to 2,500 pounds per day, a 66-2/3% reduction from the 1969 level.

J. Visitation to European and U.S. Plants - Anaconda personnel again visited various plants in the U.S. and Canada to determine if there was any device or system including wet scrubbers which was in use or could be modified for application to the Columbia Falls plant to further reduce emissions through either a primary or secondary system. A team of Anaconda technical personnel recently went to Europe to see what pollution control devices were available. Consultants from other major aluminum producers were contacted and reviewed the problem. Nothing was discovered which would control the roof emissions of the vertical stud Soderberg at Columbia Falls within Montana's prescribed limits.

1972 was the first year to demonstrate the full effect of the previous years' work in improvements of the plant and operations. A full year of testing demonstrated that the 2,500 pounds per day average fluoride output reported to the State Board of Health could be maintained.

The problem of particulate emissions was given attention concurrently with the fluoride problem. The following test work was performed leading to plant modification.

K. Wide Anodes - It was determined that a wider anode would reduce the current density which in turn would reduce the temperature at the top of the anode. The reduction of temperature would reduce the emissions from the anode escaping as particulate from the potroom roofs. This was done to all anodes at a cost of $229,200.

L. Anode Cooling Fins - Aluminum fins were imbedded in the anode paste at the top of the anode in an attempt to cool the paste and thus reduce particulate emissions out of the roofs of the potrooms. The test was made on several cells and it was found that the temperature was not significantly reduced to lower the anode temperature.

M. Anode Pin Tips - It had been the practice to permit the steel pins to be used in the cell until seven inches at the tip were used. As a result of study a change was made to reduce this to five inches. This provides for a cooler anode, better current distribution and lower particulate emissions from the cell.

N. Installation of Potline Computers - A computer program is being installed. To date three potlines have been fully computerized. The other two potlines will be computerized in the near future. The computer program automatically controls and checks voltage levels, and produces a more uniform operation. Specifically, there are fewer "sick pots" and much less open skirt area. Emissions from the plant should be reduced. The cost of this project is estimated at $600,000.

O. Drain Line Pump - Pumps have been installed to pull the scrubber effluent from the scrubber lines to the waste treatment plant. This should prevent scrubber shut down for cleaning drain lines plugging as a result of deposits on the walls of the piping.

P. Use of Petroleum Pitch and Fluid Coke - Tests using petroleum pitch and fluid coke in an attempt to reduce the hydrocarbons and thus prevent the particulate discharge at the top of the anode are being made.

These efforts illustrate Anaconda's diligence and good faith efforts in studying, identifying and correcting its environmental problems on the basis of demonstrated feasibility.

V. PROPOSED ADDITIONAL AIR POLLUTION CONTROL EFFORTS.

At present there seem to be only three additional air pollution control strategies which could reduce the current level of the plant's emissions. The first would be to convert the plant to so-called "pre-bake" anodes. Such a conversion would cost approximately $80 million and would raise production costs to a point which would make the plant uneconomical.

A second possibility is the installation of roof scrubbers. The use of wet roof scrubbers has been investigated in depth and Anaconda continues to study the possibility of their use carefully. To date the use of roof scrubbers has been rejected for several reasons. First, wet scrubbers could not be operated on the roof of the plant during the sub-freezing weather which is experienced for many months of the year at the Columbia Falls plant. Second, since the plant is a Soderberg plant, there are high levels of pitch present in the fumes which are fed through the scrubbers, resulting in deposits on the fans and clogging. These problems result in high maintenance costs. High levels of fluoride in the scrubbing medium also results in corrosion and deterioration of the scrubbing system. Perhaps most discouraging of all the factors is the simple fact that even if roof scrubbers were installed they would not be capable of meeting the Montana standard. Montana's standard is approximately 1.75 pounds of fluoride per ton per day.[1] The better of the two vertical stud Soderberg plants where roof scrubbers have been installed, at The Dalles in Oregon, had fluoride emissions in excess of 2 pounds per day per ton during 1972. The same plant returns the acid-laden effluent to the river, and its roof scrubbers were out of operation for two months during last year due to freezing weather conditions. The Columbia Falls plant experiences sub-freezing weather for much longer periods each year than at The Dalles. Thus, it appears that wet roof scrubbers are not a feasible or desirable alternative for the Columbia Falls plant from either an ecological or an economic standpoint.

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[1] Arrived at by applying Montana's 864 pounds per day limitation to the Company's production of approximately 500 tons per day.

There is, however, a third alternative which the company is actively considering, namely, the use of foam scrubbing equipment. Such equipment has been installed only on stacks of various types of industrial plants. It uses a recyclable foam scrubbing medium, and it may be able to meet the Montana standard. A team of Anaconda technical personnel has recently visited a plant using such equipment and is evaluating its application to the Columbia Falls plant. A $50,000 foam scrubbing unit has been ordered and will be delivered in August 1973. The unit will be tested for a period of six months. If economic and operational factors prove satisfactory, a second foam scrubbing unit will be installed on a sixty foot section of the roof line of one potroom by June of 1974 at an estimated capital cost of $95,000. This installation would be tested and evaluated for an entire season of twelve months, and again, assuming satisfactory economic and operational factors would be installed on the entire roof of a pot room, at an estimated capital cost of $1,450.000. Thereafter, depending on satisfactory performance, additional installations would be made toward meeting Montana standards.

Anaconda Aluminum intends to continue not only to apply the best available technology to its Columbia Falls plant, but to diligently strive to develop new technology which can be practically applied to the Columbia Falls plant. It is with that purpose and for that reason that Anaconda Aluminum applies for a one year variance, subject to renewal for such additional time period as may be required for achievement of a practical solution to meet Montana's strict air pollution control standards.

VI. NO HARM TO PUBLIC HEALTH OR SAFETY WILL RESULT FROM GRANTING THE VARIANCE.

There are no effects on human health or safety which result from the plant's emissions of fluorides and particulates. Ambient air samples at the highest levels of concentration sampled within the vicinity of the plant range between 0.1 parts per billion to 3.5 parts per billion at a maximum. These levels are far below those at which any effect on human health or safety would be experienced. Not a single case of fluorosis in humans has been encountered in the plant's history, nor has any other adverse effect on human health or safety been shown to exist.

VII. ADVANTAGES AND DISADVANTAGES RESULTING FROM GRANTING OR DENYING THE VARIANCE.

In order to grant the variance requested by Anaconda Aluminum, the Board must find that the emissions occurring or proposed to occur do not constitute a danger to public health or safety and that compliance with the Montana standard would produce hardship without equal or greater benefits to the public. Anaconda Aluminum submits and intends to prove that this is indeed the case. Anaconda Aluminum believes that the granting of the variance is fully consistent with and will aid in implementing the policy and purpose of the Clean Air Act of Montana:

> "...to achieve and maintain such levels of air quality as will protect human health, safety, and to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state and facilitate the enjoyment of the natural attractions of this state." Section 69-3905, Revised Code of Montana.

Compliance today with Montana's air pollution control regulations is only possible by closing the plant. The alternative is to grant a variance to enable the plant to continue to operate. The hardship to the public, the Anaconda Company and its employees and the benefits, if any, resulting from requiring compliance will be discussed in terms of the disadvantages of requiring compliance with the Montana Regulation for aluminum reduction plants.

A. Disadvantages resulting from requiring compliance.

As stated above, the only manner of obtaining compliance with the Montana standard by June 30, 1973 is the closing of the plant. The plant currently provides employment for 911 residents of the Flathead Valley earning a total of approximately $9.5 million per year. Since opportunities for employment are very limited in the Flathead Valley and there is already substantial unemployment in the Valley, the closing of the plant would result in unemployment for most of these employees.

Through the multiplier effect the plant's $9.5 million income to the Valley is spent approximately seven to ten times. This income contributes substantially and indispensably to the economic well-being of the entire Valley. This income is used for the purchase of a substantial portion of virtually all of the goods and services produced in the Flathead Valley and its absence would certainly cause a depression in the economy of the Flathead Valley.

Anaconda Aluminum pays ad valorem taxes on the Columbia Falls plant in an annual amount of $1,380,000.00. This constitutes 14.3% of the tax revenue of Flathead County, Montana. Loss of this revenue would mean cuts in school budgets, highway and road construction and maintenance, social services, and all public activities of the county. At the same time, the burden on public revenues would be increased by the welfare and unemployment compensation payments resulting from closing the plant. In addition to public revenues paid to Flathead County, Anaconda Aluminum and its employees pay very substantial income taxes both to the State of Montana and the United States. Again, a cut in these revenues could cause a loss of public services.

In addition to the direct effect on the Flathead Valley, an additional 1,754 employees of Anaconda throughout the United States are engaged in fabrication of the aluminum produced by the Columbia Falls plant and would lose their jobs with its closing. These employees earn a total of $20 million per year. Anaconda also has a depreciated capital investment in the Columbia Falls plant of $67 million and a depreciated capital investment in the fabricating facilities dependent upon the plant of $32 million. Altogether, a closing of the Columbia Falls plant would result in the direct loss of approximately $30 million in income, approximately $100 million in plant investment and several million dollars in public revenues.

The losses, of course, would not end with these direct losses. There would be significant losses to the numerous suppliers of the plant, including railroads, grocers, merchants, and numerous other enterprises which serve the populace of the Flathead Valley.

Customers who purchase the plant's aluminum production would also be adversely affected. Aluminum is a vital metal in the nation's economy which fortunately lends itself to recycling, an increasingly important ecological factor in the use of metals.

B. Advantages of requiring compliance.

There would be little advantage to the Flathead Valley or the State of Montana from requiring a closing of the plant. Benefit in terms of reduction of air contaminants would be mainly aesthetic and confined to the local vicinity of the plant itself. As indicated above, there is no damage to human health or safety; nor is there any danger from eating plants or vegetables grown in the Columbia Falls area.

There is a limited effect upon the most sensitive forms of vegetation in the immediate vicinity of the plant. According to several experts on vegetation, the paving of dusty streets in Columbia Falls would do far more to improve the health of the vegetation of the Columbia Falls area than the closing of the plant. The amount of damage done to vegetation, which is speculative, would in any case be a tiny fraction of the economic impact which the closing of the plant would cause.

On the basis of the information supplied herein, Anaconda Aluminum requests an exemption from compliance with the applicable Board regulations for one year for its Columbia Falls plant. The granting of this exemption will enable the company to continue to operate at its Columbia Falls plant with the maximum available technically and economically feasible air pollution control equipment.

Anaconda Aluminum will be pleased to supply the Board with any additional information that it may desire with respect to this Petition.

Respectfully submitted,

ANACONDA ALUMINUM COMPANY
DIVISION OF THE ANACONDA COMPANY

By____________________

Dated: June 30, 1973

16-2.14(1)-S1430 PARTICULATE MATTERS, INDUSTRIAL PROCESSES (1) No person shall cause, suffer, allow, or permit to be discharged into the outdoor atmosphere from any operation, process or activity, except fuel burning equipment and incinerators particulate matter in excess of the amount shown in the following table. When the process weight falls between two values in the table, the maximum weight discharged per hour shall be determined by interpolatin.

When the process weight exceeds 60,000 pounds per hour, the maximum allowable weight discharged per hour will be determined by use of the following equation:

$$E = 55.0\ P^{0.11-40}$$

Where E = Maximum rate of emission in pounds per hour, P = Process weight rate in tons per hour.

Process Weight Rate		Rate of Emission
lb/hr	Tons/hr	lb/hr
100	0.05	0.551
200	0.10	0.877
400	0.20	1.40
600	0.30	1.83
800	0.40	2.22
1,000	0.50	2.58
1,500	0.75	3.38
2,000	1.00	4.10
2,500	1.25	4.76
3,000	1.50	5.38
3,500	1.75	5.96
4,000	2.00	6.52
5,000	2.50	7.58
6,000	3.00	8.56
7,000	3.50	9.49
8,000	4.00	10.4
9,000	4.50	11.2
10,000	5.00	12.0
12,000	6.00	13.6
16,000	8.00	16.5
18,000	9.00	17.9
20,000	10.00	19.2
30,000	15.00	25.2
40,000	20.00	30.5
50,000	25.00	35.4
60,000	30.00	40.0
70,000	35.00	41.3
80,000	40.00	42.5
90,000	45.00	43.6
100,000	50.00	44.6
120,000	60.00	46.3
140,000	70.00	47.8
160,000	80.00	49.0
200,000	100.00	51.2
1,000,000	500.00	69.0
2,000,000	1,000.00	77.6
6,000,000	3,000.00	92.7

Interpolation of the data in this table for process weight rates up to 60,000 lb/hr shall be accomplished by use of the equation:

$E = 4.10\ P^{0.67}$.

Interpolation and extrapolation of the data for process weight rates in excess of 60,000 lb/hr shall be accomplished by use of the equation:

$E = 55.0\ P^{0.11} - 40$.

Where E = rate of emission in lb/hr and P = process weight rate in tons/hr.

16-2.14(1)-S1460 VISIBLE AIR CONTAMINANTS, RESTRICTIONS

(1) Restriction of Existing Installations

No person shall cause, suffer, allow or permit emissions from any installations which are:

(a) Of a shade or density darker than that designated as No. 2 on the Ringelmann Chart, or

(b) Of such opacity as to obscure an observer's view to a degree greater than does smoke described in subsection (1)(a) of this regulation.

This section does not apply to existing incinerators or existing wood waste burners.

(2) Restriction of New Installations and All Incinerators

No person shall discharge into the atmosphere from any single source of emission whatsoever any air contaminant:

(a) Shade or density darker than that designated as No. 1 on the Ringelmann Chart, or

(b) Of such opacity as to obscure an observer's view to a degree greater than does smoke described in subsection (2)(a) of this regulation.

(3) The provisions of sections (1) and (2) of this rule shall not apply to emissions during the building of a new fire, cleaning of fires or soot blowing, the shade or density of which is less than No. 3 on the Ringelmann Smoke Chart or of such opacity as to obscure an observer's view to a degree greater than does smoke designated as No. 3 on the Ringelmann Smoke Chart for a period or periods aggregating no more than four minutes in any 60 minutes.

Where the presence of uncombined water is the only reason for failure of an emission to meet the requirements of sections (1) and (2) of this regulation, such sections shall not apply.

The provisions of section (1) of this regulation shall not apply to the following:

(a) Transfer of molten metals.

(b) Emissions from transfer ladles.

16-2.14(1)-S14080 ALUMINUM PLANTS, FLUORIDE EMISSIONS

(1) No person or persons shall cause, suffer, allow or permit to be discharged into the outdoor atmosphere from any primary aluminum reduction plant, aluminum smelter or aluminum manufacturing plant either in a gaseous or particulate form or any combination of gaseous or particulate forms fluorides in excess of 0.060 pounds per hour per reduction cell commonly called a "pot". For operations producing aluminum at an annual rate of more than 200,000 tons, the combined emission of fluorides into the outdoor atmosphere from all pots regardless of the number shall not exceed 40.0 pounds per hour. The total of all particulate matter including particulate fluoride emitted from all of the pot rooms combined shall not exceed that allowed under MAC 16-2.14(1)-S14030 or MAC 16-2.14(1)-S1460 formulated under the Clean Air Act of Montana.

(2) Definitions:

"Reduction cell" or "pot" means a shallow carbon-lined steel vessel (cathode) containing molten cryolite and aluminum into which is suspended a carbon anode.

"Pot room" means a large building or room which houses up to several hundred pots or reduction cells.

"Plant" means primary aluminum reduction plant, aluminum smelter or aluminum manufacturing plant.

(3) Unless the gaseous portion of the fluorides emitted at any fluorides emission point is more than 50 percent of the total fluorides emitted, the results of sampling may be reported on a total fluoride basis. Sampling under such circumstances may be done without differentiation between gaseous and particulate phases of the emissions but all emitted fluorides must be collected as completely as possible.

Each existing plant to which this rule applies shall submit to the director, at least 90 days before the effective date of this rule, a detailed monitoring program including, but not limited to, the following:

(a) A description of monitoring equipment and procedures capable of determining compliance with this regulation.

(b) A description of the sources to be monitored which shall include the stack of any fluoride scrubber or any fluoride or particulate emission control device or emission point at the pots or pot rooms.

(i) Unless otherwise authorized by the director, data for each calendar month shall be reported by each plant not later than 15 days after the end of each calendar month.

(ii) The data submitted must include the average daily emission of fluorides, as total fluorides, expressed in pounds per hour per operated pot. A pot must operate 75 percent of the time during the reporting period to qualify as an operating pot.

(iii) The number of pots operating during the reporting period must be reported.

(c) Within 30 days after approval of the detailed monitoring program by the director, the approved equipment shall be ordered by the plant. Within 30 days after receipt of the approved equipment from the vendor, the equipment shall be installed and operating. Reporting of the results shall begin as provided for in section (2) at the end of the calendar month in which the monitoring equipment is installed and each month thereafter as indicated.

Each plant shall furnish, upon request of the director, such other pertinent data as may be required to evaluate the plant's emission control program.

(4) The effective date of this rule shall be June 30, 1970 for new plants and June 30, 1973, for existing plants.

16-2.14(1)-S14080 ALUMINUM PLANTS, FLUORIDE AND PARTICULATE EMISSIONS (1) No person or persons shall cause, suffer, allow or permit to be discharged into the outdoor atmosphere from any primary aluminum reduction plant, aluminum smelter or aluminum manufacturing plant either in a gaseous or particulate form fluorides in excess of 0.060 pounds per hour per reduction cell commonly called a "pot". For operations producing aluminum at an annual rate of more than 200,000 tons, the combined emission of fluorides into the outdoor atmosphere from all pots regardless of the number shall not exceed 40.0 pounds per hour.

(2) Unless the gaseous portion of the fluorides emitted at any fluorides emission point is more than 50% of the total fluorides emitted, the results of sampling may be reported on a total fluoride basis. Sampling under such circumstances may be done without differentiation between gaseous and particulate phases of the emissions but all emitted fluorides must be collected as completely as possible.

Each existing plant to which this rule applies shall submit to the administrator a detailed monitoring program including, but not limited to, the following:

(a) A description of monitoring equipment and procedures capable of determining compliance with this rule.

(b) A description of the sources to be monitored which shall include the stack of any fluoride scrubber or any fluoride or particulate emission control device or emission point at the pots or pot rooms.

(i) Unless otherwise authorized by the administrator, data for each calendar month shall be reported by each plant not later than fifteen days after the end of each calendar month.

(ii) The data submitted must include the average daily emission of fluorides, as total fluorides, expressed in pounds per hour per operating pot. A pot must operate at least 75% of the time during the reporting period to qualify as an operating pot.

(iii) The number of pots operating during the reporting period must be reported.

(c) Within thirty days after approval of the detailed monitoring program by the administrator, the approved equipment shall be ordered by the plant. Within thirty days after receipt of the approved equipment from the vendor, the equipment shall be installed and operating. Reporting of the results shall begin as provided for in section (2) at the end of the calendar month in which the monitoring equipment is installed and each month thereafter as indicated.

Each plant shall furnish, upon request of the administrator, such other pertinent data as may be required to evaluate the plant's emission control program.

(3) No person or persons shall cause, suffer, allow or permit to be discharged into the outdoor atmosphere from any primary aluminum reduction plant emissions of

particulate matter in excess of 0.33 pounds per hour per reduction cell, or 9.4 pounds per ton of aluminum produced per 24 hours, whichever is the lesser.

(4) No owner or operator of any primary aluminum reduction plant or aluminum smelter subject to the provisions of section (3) of this rule shall operate such facility unless all particulate matter emitted from such facility is collected by an exhaust gas system and treated in such manner as to comply with section (3) of this rule prior to venting to the atmosphere. The height of emissions release shall reflect good engineering practices.

(5)(a) The test methods and procedures used to determine compliance with section (3) of this rule are set forth below. The methods referenced by number are contained in the appendix to Part 60 of Chapter 1 of Title 40, "Code of Federal Regulations," Equivalent methods and procedures may be used if approved in advance by the administrator.

(i) For each sampling repetition, the average concentration of particulate matter shall be determined by using Method 5. Traversing during sampling Method 5 shall be according to Method 1. The minimum sampling time for each repetition shall be four hours and the minimum sampling volume shall be 120 ft.^{3} (3.4m^3) corrected to standard conditions on a dry basis. The total sampling time shall be at least 24 hours.

(ii) The volumetric flow rate of the total effluent shall be determined by using Method 2. Gas analysis shall be performed by using the integrated sample technique of Method 3, and moisture content shall be determined by the condensor technique of Method 4.

(b) All primary and secondary emission testing shall be conducted while the associated pot rooms are operating at conditions representative of normal operation, and shall operate under such other relevant conditions as the administrator shall specify.

(c) The owner or operator of a primary aluminum reduction plant subject to this rule shall not later than January 31, 1976, and not less than six months prior to the certification date provided for in the compliance shcedule for the above-captioned rule [subsection (1)(a)(v)] submit to the administrator for approval a detailed monitoring program including but not limited to the following.

(i) A description of the emissions monitoring equipment and procedures capable of determining compliance with section (3) of this rule, and

(ii) The emission sampling frequency.

(d) Within thirty days after approval of the detailed monitoring program by the administrator, the approved equipment shall be ordered. Within thirty days after receipt of the approved equipment from the vendor, the equipment shall be installed and operated. The administrator shall be notified not later than thirty days after the requirements of this paragraph have been met.

(e) The following information shall be submitted to the administrator not later than thirty days after the end of each calendar month commencing with the first full month after the monitoring equipment has been installed.

(i) Primary and secondary emissions of particulate matter and total fluoride emission rates (reduced to the units of the applicable standards) recorded during the month.

(ii) Calculations supporting the data.

(iii) For each month the total elapsed time (hours) each system did not achieve at least 75% of the designed collection efficiency;

(iv) For each month, a written report of excess emissions resulting from malfunctions. The report shall include the magnitude of excess emissions (reduced to the units of the applicable standard), as measured by monitoring equipment or estimated, and the total elapsed time of excess emissions (hours). The nature and cause of any malfunction (if known), the corrective action taken and preventive measures adopted shall be reported.

(v) Such other pertinent data as may be required by the administrator to evaluate the facility's emission control program.

(6) Definitions:

"Aluminum manufacturing" means the reduction of alumina (aluminum oxide) to aluminum .

"Aluminum produced" is the amount of aluminum drawn from a pot or pots.

"Effluent" means emissions.

"Emissions" means all matter which enters the atmosphere in any form.

"Exhaust gas system" means any equipment or combination of equipment such as fans, ducts, hoods, or ventilators, used to draw off ventilation air (including air pollutants), either through natural or forced draft.

"Malfunction" means any sudden and unavoidable failure of air pollution control equipment. Failure to provide routine maintenance shall render a failure of control equipment avoidable.

"Plant" means primary reduction plant.

A "pot" is a reduction cell.

A "pot room" is a large building or room which houses up to several hundred pots or reduction cells.

"Pounds per hour" means the total number of effluent emitted in an hour from the plant.

"Pounds per hour per reduction cell" can be computed by dividing pounds of daily effluent by the product of 24 times the total number of reduction cells operated that day.

"Primary emissions" are those which are drawn from the pots and do not become part of the ambient air within a pot room.

A "reduction cell" is a shallow carbon-lined steel vessel (cathode) containing molten cryolite and aluminum into which is suspended a carbon anode.

"Secondary emissions" are all emissions other than primary emissions.

"Smelter" means primary reduction plant.

APPENDIX B
AMBIENT SAMPLING & SITE ID--EPA & SDHES

LOCATION AND ELEVATION OF FLUORIDATION NETWORK SITES

Site number	Elevation above mean sea level, feet	Location
1	3150	Glacier Park; near Fire Weather Station
2	3100	Blankenship Ranch
3	3200	Rose Ranch
4	3250	Near railroad and Blankenship Road crossing
5	3040	DeMerritt Property
6	3000	Northeast of Whitefish
7	3145	Upper Lake McDonald; at Ranger Station
8	3145	Lower Lake McDonald; near Apgar
9	3800	Camas Creek Road; on trail to Huckeberry Mountain
10	3350	North Fork Road; near Big Creek Ranger Station
11	3500	North Fork Road; 5 miles north of station 3
12	2993	Northwest end of Lake Blaine
13	2900	South of Creston; along Highway 35
14	3250	Highway 2; 2 miles south of Park headquarters
15	3400	East side of Teakettle Mountain
16	3320	North Ford Road; near Turnbull Creek turnoff
17	3100	Dehlbom property
18	3050	Badrock Canyon
19	5200	Apgar Lookout
20	3150	Park headquarters
21	3580	Vicinity of Hungry Horse Dam
22	4200	Emery Hill
23	3150	Coram
24	3400	Boehm's Bear Den
25	3280	Base of Apgar ridge
26	3400	Red Eagle; near Nyack
27	3260	Kootenai Creek; east of West Glacier
28	3145	Southeast side of Lake McDonald
30	3400	Hill above Park headquarters
32	3070	North of Morning Slough Lake
33	3050	South of Morning Slough Lake
33	3050	Southeast of Morning Slough Lake
34	3920	Teakettle Mountain; 3 miles north of Relay Tower
35	4200	Teakettle Mountain, 1.5 miles north of Relay Tower
36	3400	Hill near gravel pit, on Highway 2
37	3250	Hill above Park headquarters; 150 feet feet below site 30

EPA (19)

GLACIER [illegible]

[illegible]

[illegible]

Site Number	July	August	September	October	November	Av[illegible] Mon[illegible] Rate
1[a]	11[b]	13[b]	9[b]	10[b]	10[b]	11
2[a]	14[b]	13[b]	20[b]	11[b]	13[b]	14
3[a]	10[b]	10[b]	10[b]	4[b]	6[b]	8
4[a]	15[b]	23[b]	11[b]	12[b]	13[b]	15
5	29	30	32	16	--	27
6	15	10[b]	7[b]	4[b]	--	9
7[a]	14	9	8	7	--	10
8[a]	15	8	7	6	8	9
9[a]	10	5	4	4	--	6
10	9	5	4	2	--	5
11	9	8	3	2	--	[illegible]
12	7	--	3	2	--	4
13	10	--	4	4	--	6
14	13	12	9	5	6	9
15	17	19	14[b]	9[b]	10[b]	14
16	12	12	6[b]	5[b]	--	9
17	38	83[b]	43[b]	43[b]	23[b]	46
18	23	30[b]	21[b]	25[b]	37[b]	27
19[a]	20	29	48	22	--	30
20[a]	13	16	8	5	5	9
21	10	4[b]	5[b]	4[b]	--	6
22	8	5[b]	5[b]	3[b]	--	5
23	13	18[b]	13[b]	8[b]	16[b]	14
24[a]	9	8	5	3	--	6
25[a]	24	24[b]	26[b]	11[b]	18[b]	21
26	10	7[b]	6[b]	4[b]	--	7
27	6	7[b]	6[b]	4[b]	8[b]	6
28[a]	10	6	5	3	--	6
30[a]	--	--	--	8	8[b]	8
32	--	15[b]	9[b]	10	--	12
33	--	6[b]	5[b]	4[b]	--	5
33A	--	6[b]	5[b]	4[b]	--	5
34	--	37	41	--	--	39
35	--	--	50[b]	91[b]	--	71
36	--	--	--	--	9	9
37[a]	--	--	--	--	9	9

a Exposure sites located in or near Glacier Bay

b Value is average of two or more duplicate readings

State Department of Health and Environmental Sciences

Site Identification

0270001 - 936 9th Avenue
0270002 - N edge on top of high school
0270003 - 500 4th Avenue North

0480002 - Dehlbom's Ranch ENE of tower station
0480003 - Feirstein Ranch 40 ft. from barn
0480004 - R. E. Owen, Highway 2 South
0480005 - power substation W of Hungry Horse
0480006 - N of Col. Falls on Cedar Ridge Road
0480007 - Old Opalka Res. N of Columbia Heights
0480008 - Dehlbom Ranch N of Columbia Falls
0480009 - Sedivey Res. N Fork Road
0480012 - SE corner of Dehlbom field
0480013 - S of Anaconda plant on power tower
0480014 - half way up the W side of Teakettle
0480015 - half way up the west side of Teakettle
0480016 - near the top of Teakettle Mountain
0480017 - near the top of Teakettle Mountain
0480018 - near the top of Teakettle Mountain
0480019 - half way up Teakettle Mountain
0480020 - along south side of old logging road
0480021 - 50 ft. W of road
0480022 - 200 ft. S of large barn
0480023 - half way up Teakettle Mountain
0480024 - 1/3 way up Teakettle Mountain
0480025 - 100 ft. east of the end of the road
0480026 - 150 yds NW of Teakettle Mountain
0480028 - south side of road going to AAC
0480029 - Dehlbom's E trailer

0570003 - 100 ft. N of road
0570004 - 15 ft. from the edge of a cliff

0800007 - top of high school
0800008 - on top of Evergreen School

Std. 0.3 - 28 days
0.321 - 30 days

SDHES
AMBIENT FLUORIDE
ug/cm^2/30 days

Key: $\frac{\text{average}}{\text{maximum}}$ $\frac{\text{\# of violations}}{\text{\# of months data}}$

Station	1974		1973		1972		1971		1970		1969	
986 9th Avenue	0.155	0	0.232	3	0.242	2	0.539	6				
0270001	0.190	2	0.470	12	0.700	12	1.200	8				
High School									0.673	5	2.413	7
0270002									1.200	6	5.150	7
Jr. High School									0.960	8	2.827	9
0270003									1.410	8	6.110	9
Dehlboms	0.250	1	0.401	6	0.881	12	1.097	10	1.048	9	4.335	8
0480002	0.360	2	0.870	11	1.640	12	2.100	11	1.500	9	9.080	8
Feirstein	0.215	0	0.331	6	0.542	8	0.771	10	0.699	8	1.617	7
0480003	0.230	2	0.620	12	1.130	12	1.500	11	1.200	9	3.100	8
R. E. Owen	0.140	0	0.163	1	0.215	2	0.267	2				
0480004	0.150	2	0.500	11	0.380	12	0.430	9				
Badrock Subs.	0.240	0	0.165	0	0.412	9	0.460	9	1.163	7	1.244	8
0480005	0.240	2	0.250	12	0.610	12	0.730	11	4.800	9	3.780	8
Cedar Rdg. Rd.	0.060	0	0.060	0	0.115	1	0.063	0				
0480006	0.100	2	0.160	9	1.000	11	0.130	9				
Opalka									0.172	0	0.866	5
0480007									0.230	8	2.280	8
Dehlbom N									1.260	8	4.747	8
0480008									1.900	8	9.730	8
Sedivy									1.000	8	2.377	7
0480009									1.700	8	4.700	8
Dehlbom's Field	0.215	0	0.419	6	1.064	8						
0480012	0.230	2	0.980	11	2.700	8						

Std. 0.3 - 28 days
0.321 - 30 days

SDHES
AMBIENT FLUORIDE
ug/cm2/30 days

Key: average / maximum # of violations / # of months data

Station	1974		1973		1972		1971		1970		1969	
Anaconda So. 0480013	3.570 3.570	1 1	3.213 5.560	12 12	8.570 10.200	7 7						
F Co. H.S. 0800007									0.081 0.190	0 6	0.197 0.430	1 8
W. Evergreen 0800008									0.068 0.100	0 8	0.271 0.710	2 8
Teakettle #1 0480014			4.007 4.840	10 10	5.587 10.280	8 8						
Teakettle #2 0480015			5.408 10.850	6 6	7.451 12.070	7 7						
Teakettle #3 0480016			2.100 2.600	9 9	2.781 5.500	7 7						
Teakettle #4 0480017			3.024 3.670	5 5	2.017 4.660	2 3						
Teakettle #5 0480018			1.086 2.170	8 8	0.741 2.000	5 6						
Teakettle #6 0480019			2.861 3.880	10 10	5.357 15.730	4 4						
Hamilton #1 0480020			0.452 0.800	7 11	0.417 0.430	3 3						
Teakettle #7 0480021			0.206 0.340	1 7								
Teakettle #8 0480022			0.217 0.310	0 8								
Teakettle #9 0480023			4.930 8.200	2 2								

Std. 0.3 - 28 days
0.321 - 30 days

SDHES
AMBIENT FLUORIDE
ug/cm^2/30 days

Key: $\frac{\text{average}}{\text{maximum}}$ $\frac{\text{\# of violations}}{\text{\# of months dat}}$

Station	1974	1973	1972	1971	1970	1969
Teakettle #10 0480024	$\frac{0.160}{0.160}$ $\frac{0}{1}$	$\frac{2.932}{7.320}$ $\frac{5}{8}$				
Teakettle #11 0480025		$\frac{3.814}{13.950}$ $\frac{5}{5}$				
Teakettle #12 0480026	$\frac{3.620}{3.620}$ $\frac{1}{1}$	$\frac{4.980}{6.620}$ $\frac{6}{6}$				
Alum City 0480028	$\frac{0.205}{0.230}$ $\frac{0}{2}$	$\frac{0.425}{1.060}$ $\frac{5}{10}$				
Tailer 0480029	$\frac{0.285}{0.450}$ $\frac{1}{2}$	$\frac{0.240}{0.370}$ $\frac{1}{3}$				
Glacier Park #1 0570003		$\frac{0.073}{0.080}$ $\frac{0}{3}$				
Glacier Park #2 0570004		$\frac{0.140}{0.160}$ $\frac{0}{3}$				

POLYNUCLEAR HYDROCARBON ANALYSIS
OF
AIR IN FLATHEAD VALLEY

			UG/G BS*	UG/G PART**	UG/1000CU M***
CRESTON	Fluoranthene	- FLT	298.6	21.5	2.1
	Pyrene	- PYR	286.9	20.7	2.0
	Benz(a)anthracene	- BAA	75.9	5.5	0.5
	Chrysene	- CHY	356.5	25.7	2.5
	Benzo(e)pyrene	- BEP	219.1	15.8	1.5
	Benzo(a)pyrene	- BAP	167.3	12.1	1.2
	Perylene	- PER	17.3	1.3	0.1
	Benzo(g,h,i)perylene	- GEE	115.6	8.3	0.8
	Anthanthrene	- ANT	7.6	0.5	0.1
	Coronene	- COR	37.2	2.7	0.3
KALISPELL		FLT	356.0	41.6	4.5
		PYR	366.9	42.8	4.7
		BAA	96.8	11.3	1.2
		CHY	394.1	46.0	5.0
		BEP	270.1	31.5	3.4
		BAP	234.7	27.4	3.0
		PER	25.6	3.0	0.3
		GEE	187.5	21.9	2.4
		ANT	8.4	1.0	0.1
		COR	82.3	9.6	1.0
COLUMBIA FALLS		FLT	258.3	12.6	2.7
		PYR	250.0	12.2	2.6
		BAA	251.3	12.3	2.7
		CHY	844.8	41.2	8.9
		BEP	782.9	38.2	8.3
		BAP	783.0	38.2	8.3
		PER	70.3	3.4	0.7
		GEE	429.8	21.0	4.5
		ANT	24.5	1.2	0.3
		COR	91.7	4.5	1.0

*Micrograms of hydrocarbon per gram of Benzene Soluble Tar.
**Micrograms of hydrocarbon per gram of Total Particulate.
***Micrograms of hydrocarbon per 1000 cubic meters of air.

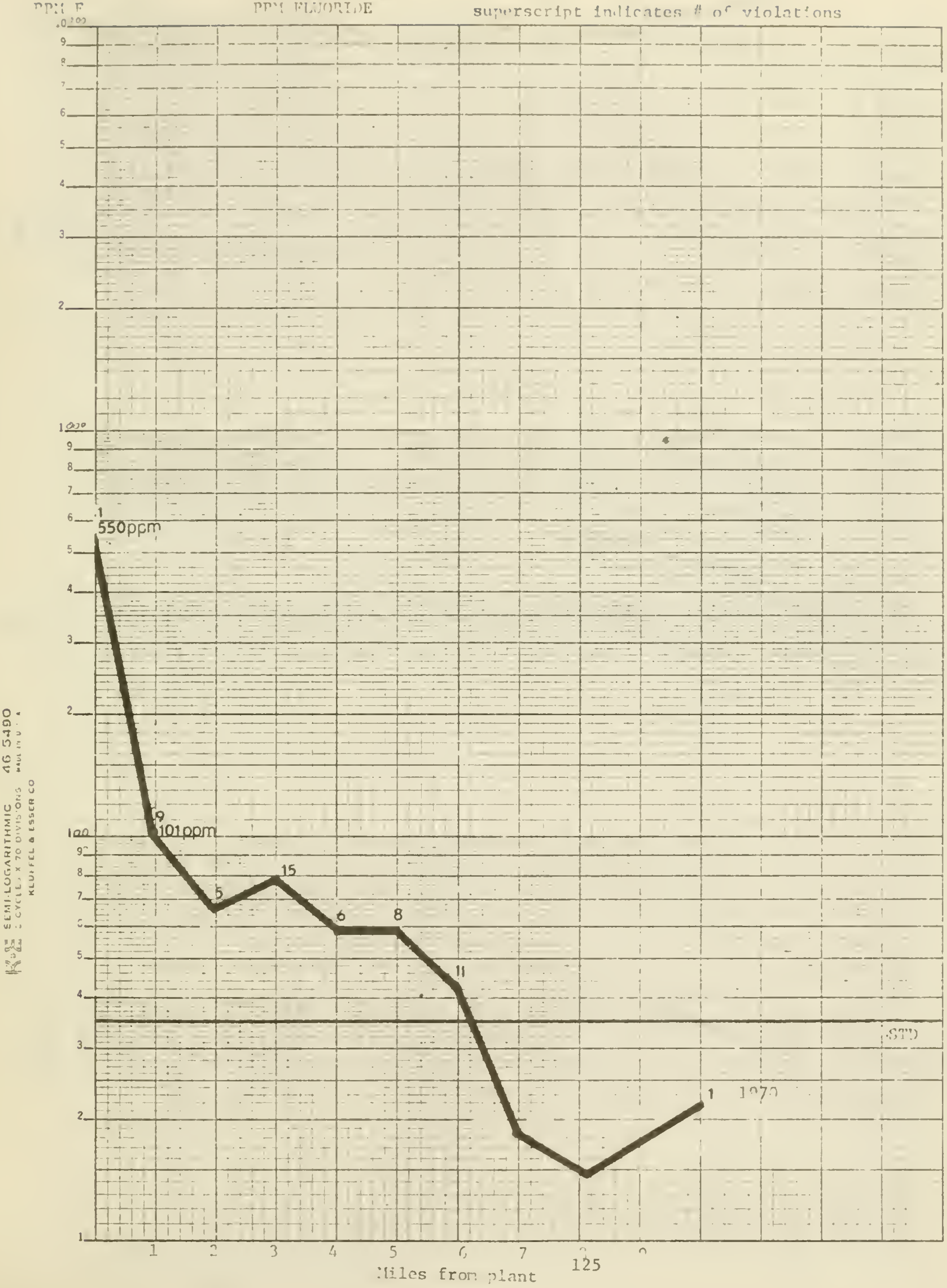
State Dept of Health (20)

APPENDIX C
FLUORIDE IN VEGETATION--SDHES DATA

CONIFER SAMPLES
PPM FLUORIDE

SDHES
superscript indicates # of violations

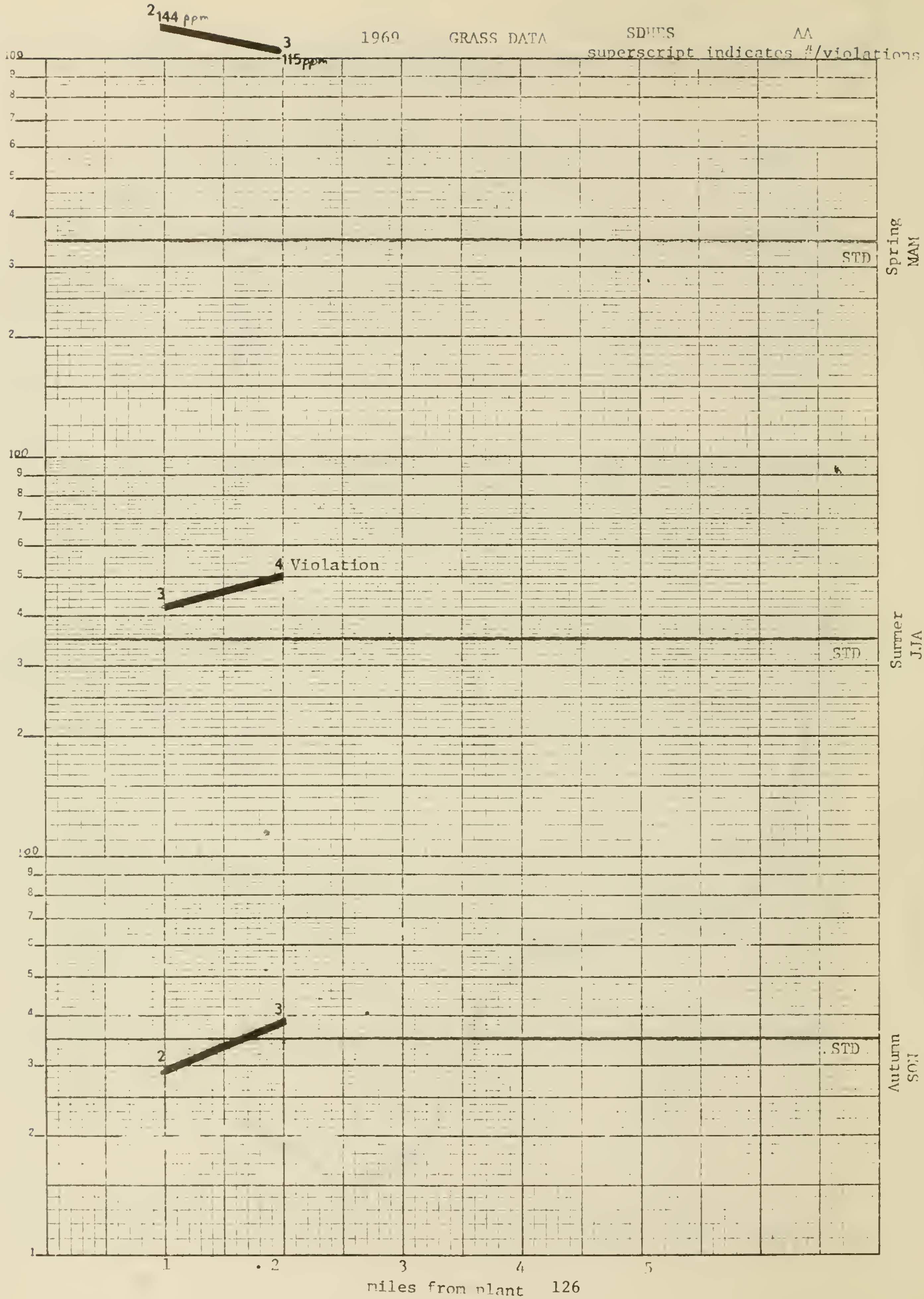
AA



Summer

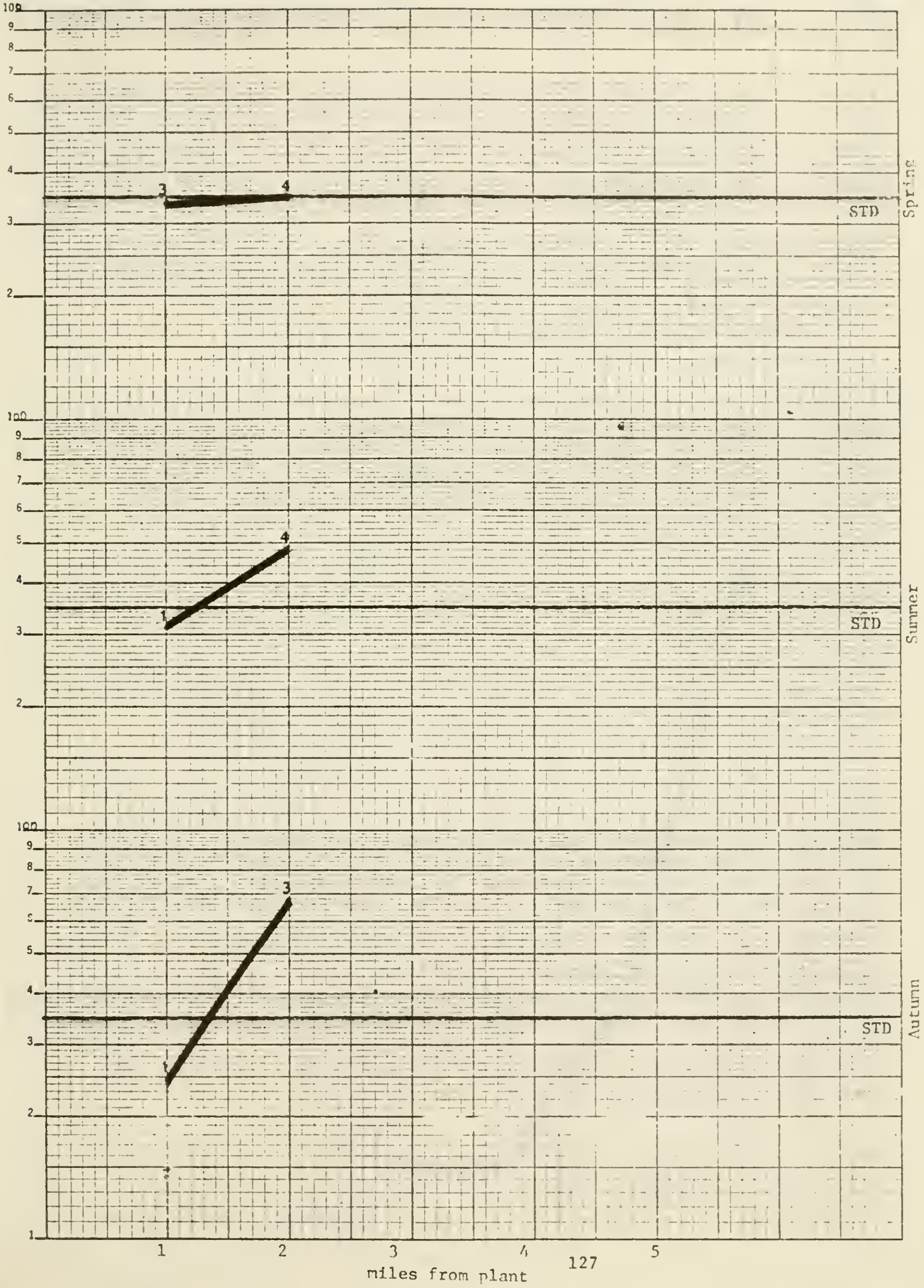
1969 GRASS DATA SDHES AA

superscript indicates #/violations

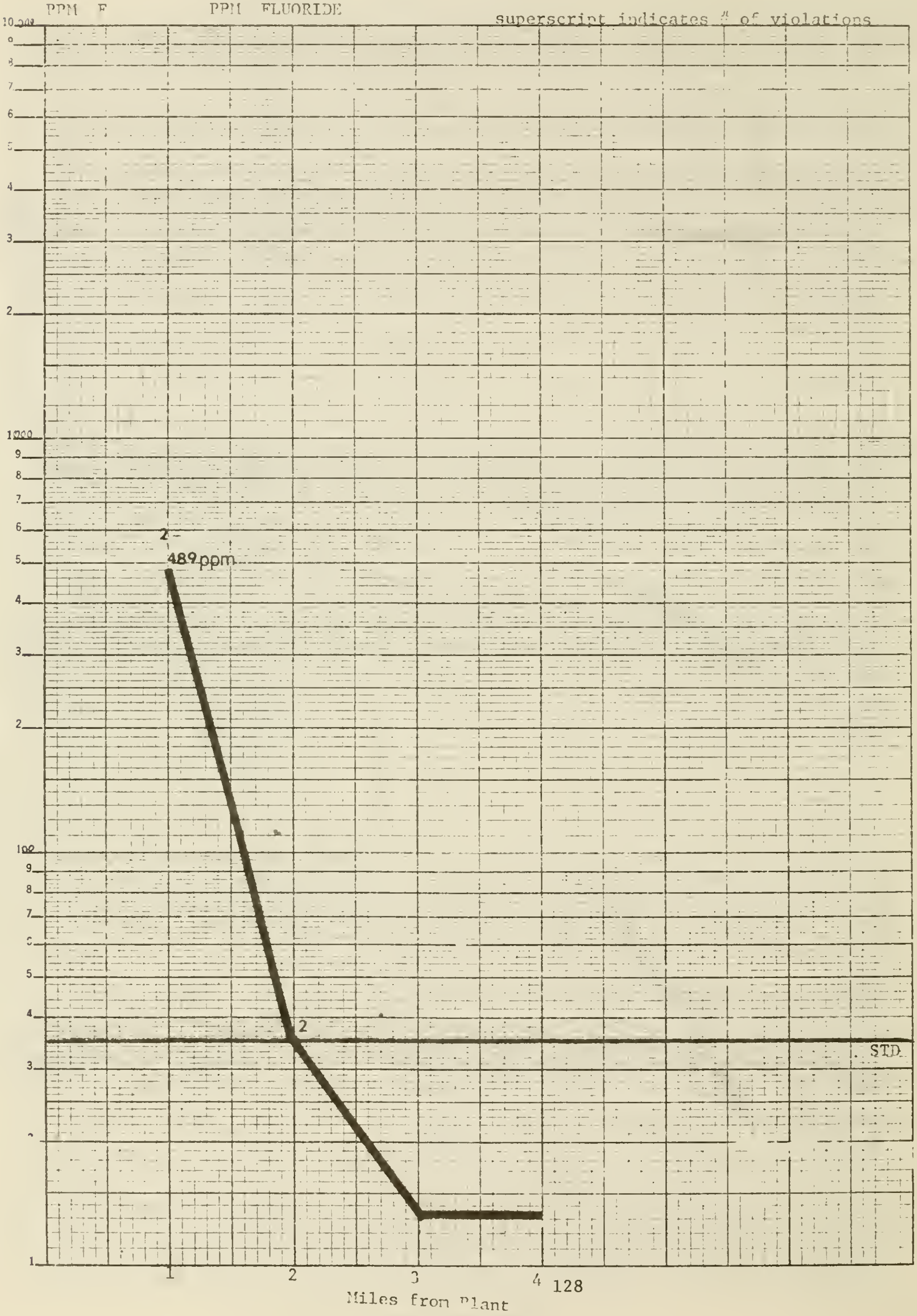


SEMI-LOGARITHMIC 46 5490
KEUFFEL & ESSER CO.

1970 GRASS DATA SDHES



NEW GRASS SAMPLES SDHES AA
PPM FLUORIDE

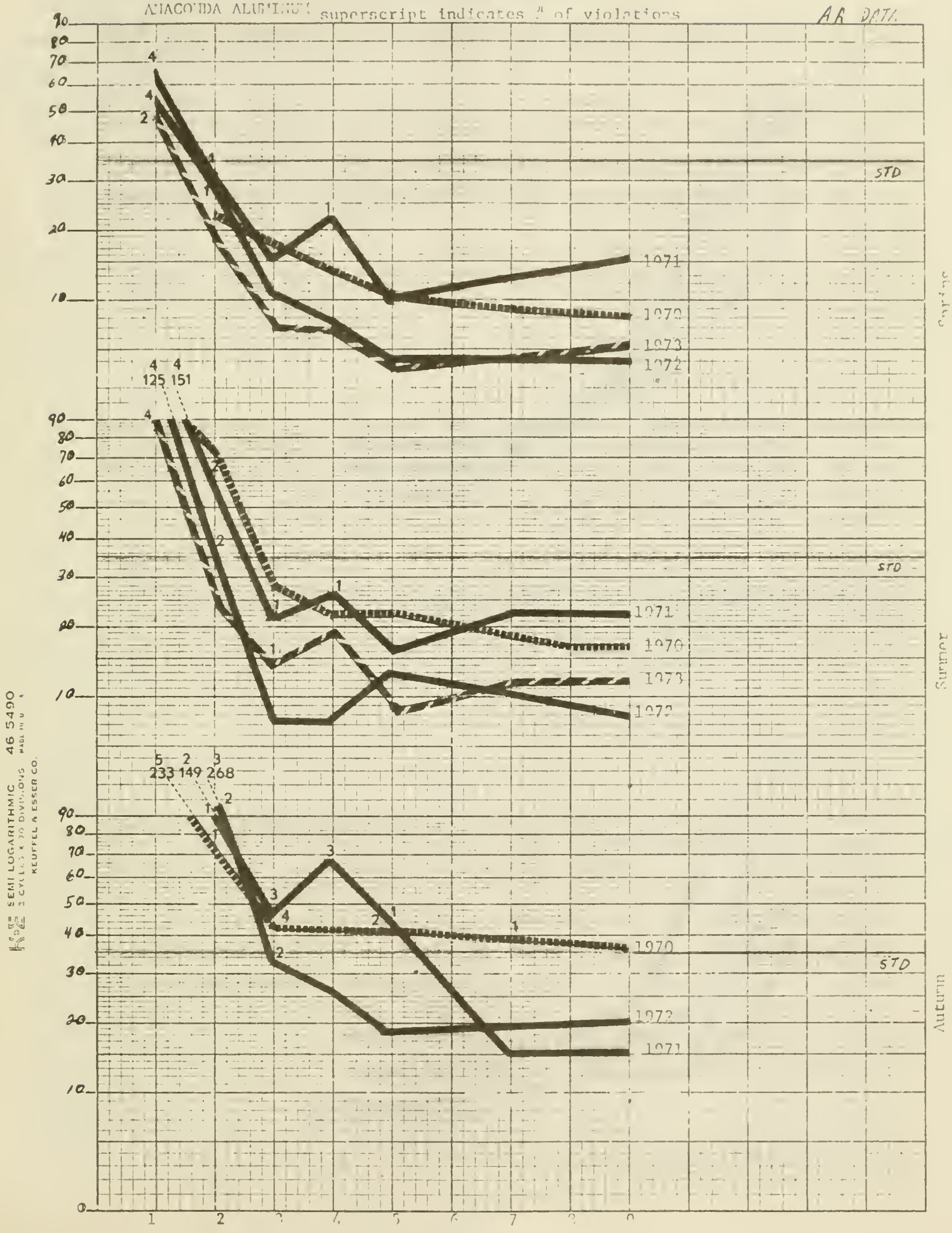


Spring 1973
man

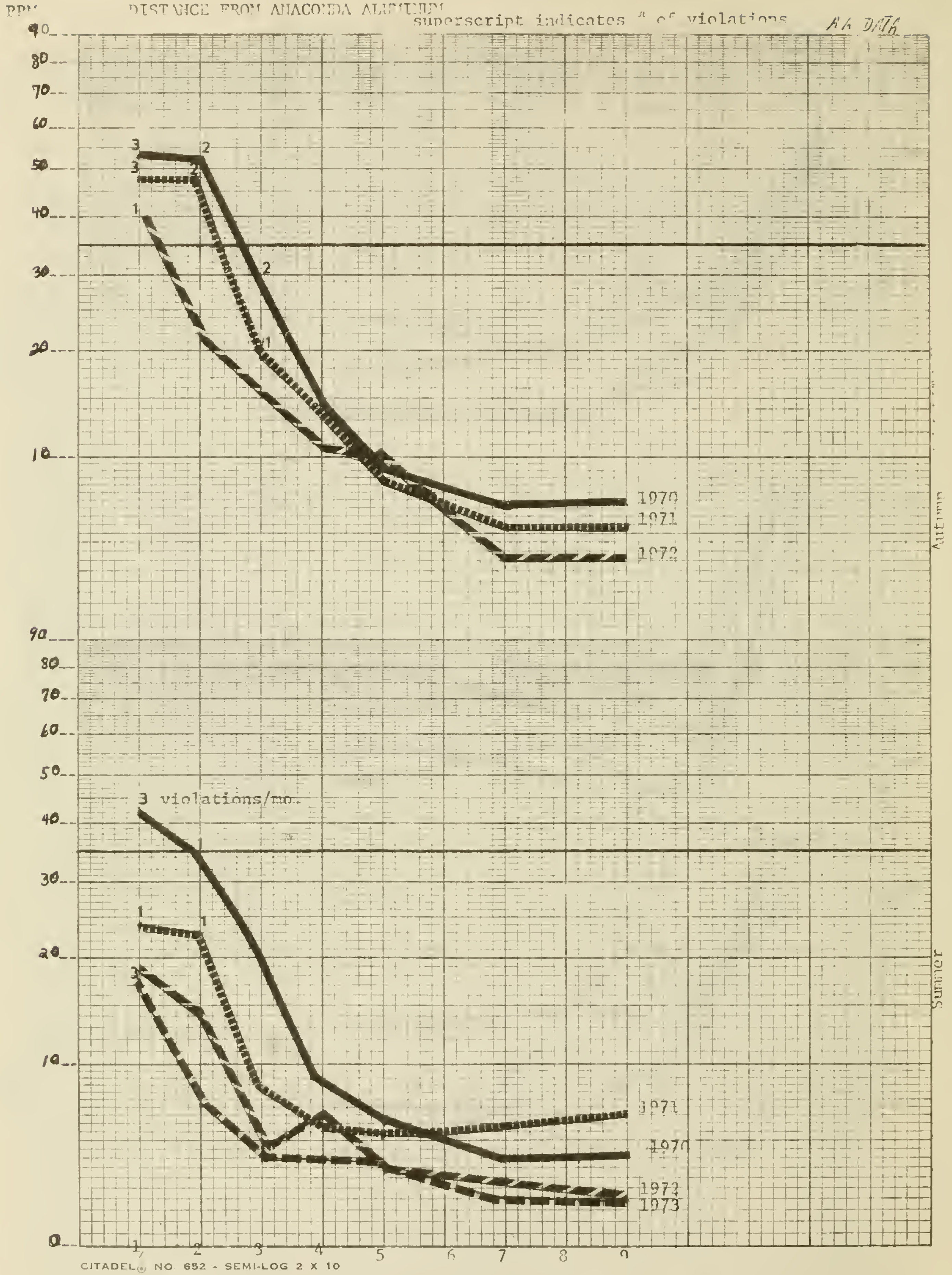
SEMI LOGARITHMIC 46 5490
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

APPENDIX D
FLUORIDE IN VEGETATION--AAC DATA

LEVELS OF F (PPM) IN GRASS WITH INCREASING DISTANCE FROM ANACONDA ALUMINUM superscript indicates # of violations



LEVELS OF F (PPM) IN PINE (CURRENT GROWTH) WITH INCREASING DISTANCE FROM ANACONDA ALUMINUM



ppm Fluoride in Pine Samples
Collected at Various Sites

		1970			1971			1972			1973		
Distance	Site #	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
1 mile	2		10.5	13		3	5		3	5		3	
	6		16	23		32	34		6	20		23	
	7		46	60		34	65		38	56		13	
	19		30.5	40.5		10	44		17	44		16	
	155		107.5	131		42	88		29	77		31	
	x̄		42.1	53.5		24.2	47.2		18.6	40.4		17.2	
2 mile	51		4	5		2	6		0	5		2	
	152		72	90		25	61		11	29		13	
	156		24.5	61.5		42	77		31	31		8	
	x̄		33.5	52.16		23.0	48.0		14.0	21.66		7.66	
3 mile	127		23	25		7	8		2	19		3	
	128		32	14		9	13		2	18		3	
	161		23.5	53		15	66		13	25		8	
	162		27.5	38		9	17		-	-		7	
	163		6	8.5		5	4		1	8		3	
	168		7	-		3	4		-	8		3	
	x̄		19.83	28.37		8.0	18.66		4.5	15.6		4.5	
4 mile	120		6	8		3	4		4	4		1	
	136		8	24		12	27		8	17		6	
	157		10.5	9		3	13		13	10		5	
	x̄		8.17	13.67		6.0	14.67		8.33	10.33		4.0	
5 mile	40	37	10	9		8	9		5	7		3	
	119	-	7	8		4	8		4	8		2	
	148	-	4	10.5		5	7		1	14		5	
	x̄		7.0	9.17		5.67	8.0		3.33	9.67		3.33	
7 mile	42		4	6		4	4		0	3		1	
9 mile	135		4	8.5		9	7		2	4		3	

ppm Fluoride in Grass Samples
Collected at Various Sites

Distance	Site #	1970			1971			1972			1973		
		Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
1 mile	2		21	40.5	14	24	24	14	6	20	6	8	
	6		117	259	57	155	163	69	81	60	21	80	
	7		206	356	55	178	262	42	236	755	112	88	
	19		104	98.5	57	180	-	46	105	-	29	114	
	155		165	413.5	161	220	-	96	198	238	71	129	
	x̄		122.6	233.5	68.8	151.4	149.6	53.4	125.2	268.25	47.8	83.8	
2 mile	51	22	8.5	12	22	5	14	10	6	14	4	10	
	152	-	189.5	-	51	118	170	51	49	241	29	-	
	156	-	17.5	138.5	22	57	-	-	52	64	23	38	
	x̄	22	71.83	75.25	31.67	60.0	92.0	30.5	35.67	106.33	18.67	24.0	
3 mile	127	9	39.5	485	18	30	41	1	7	43	9	18	
	128	16	18	35	24	22	33	6	2	20	4	6	
	161	-	42.5	63	13	35	70	27	5	-	8	35	
	162	-	27	61	9	18	109	12	13	33	7	13	
	163	-	11.5	17	8	13	15	5	5	8	5	5	
	168	-	-	29	21	20	21	11	14	58	7	10	
	x̄	12.5	27.7	41.0	15.5	23.0	48.17	10.33	7.67	32.4	6.67	14.5	
4 mile	120	10	28	34	9	24	40	8	6	20	5	25	
	136	31	19	-	45	37	98	7	14	34	8	72	
	157	-	21.5	24	14	19	63	8	3	27	7	18	
	x̄	20.5	22.83	29.0	22.67	26.67	67.0	7.67	7.67	27.0	6.67	18.33	
5 mile	40	17	27.5	76	10	28	62	7	30	31	2	16	
	119	3	7.5	7	5	9	-	2	3	7	6	10	
	148	-	39	38	14	11	26	2	7	17	2	3	
	x̄	10.0	24.67	40.33	9.67	16.0	44.	3.67	13.33	18.33	3.33	9.67	
7 mile	42	9	24.5	45	19	22	17	6	13	29	6	15	
9 mile	135	7	14	33.5	8	22	13	3	2	9	4	9	

APPENDIX E
AMBIENT SAMPLING--AAC DATA

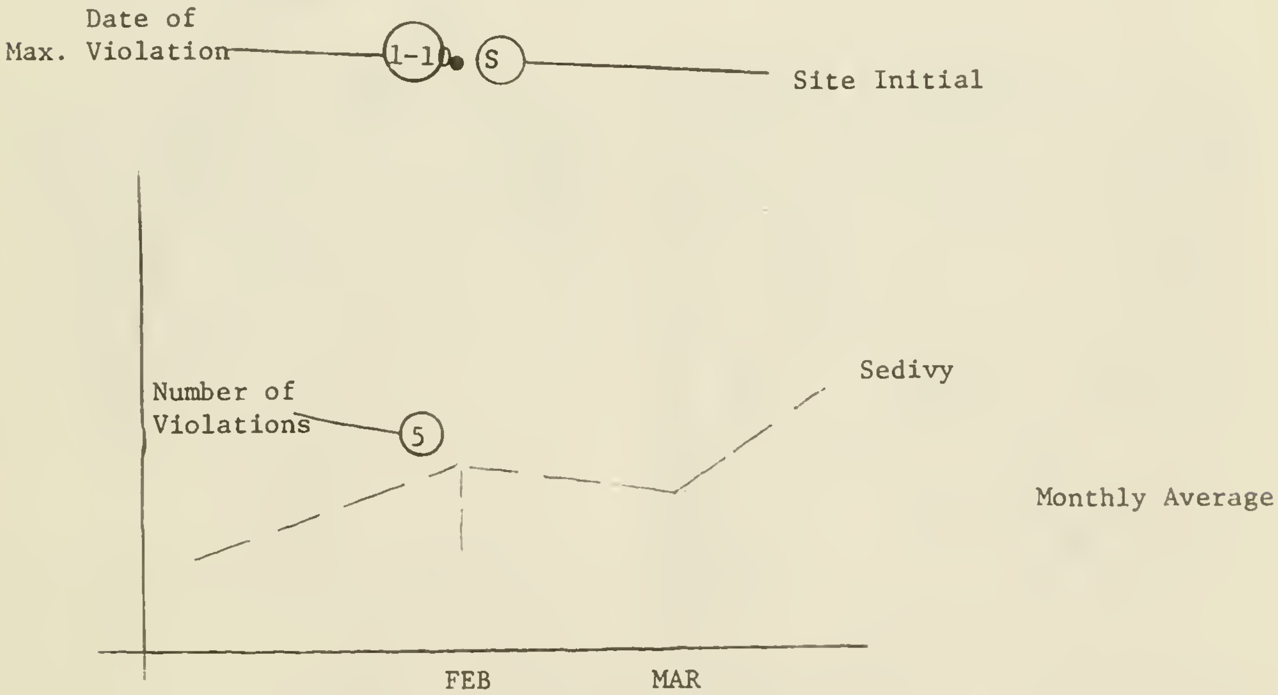
E.1 Graphical Summary of AAC Data 1970-1974

Explanation of Graphs

The coded lines signify monthly averages of total fluorides in PPB for the noted station.

A break in the coded lines denotes missing data for the period. The numbers on the monthly average lines are the number of violations recorded during the month.

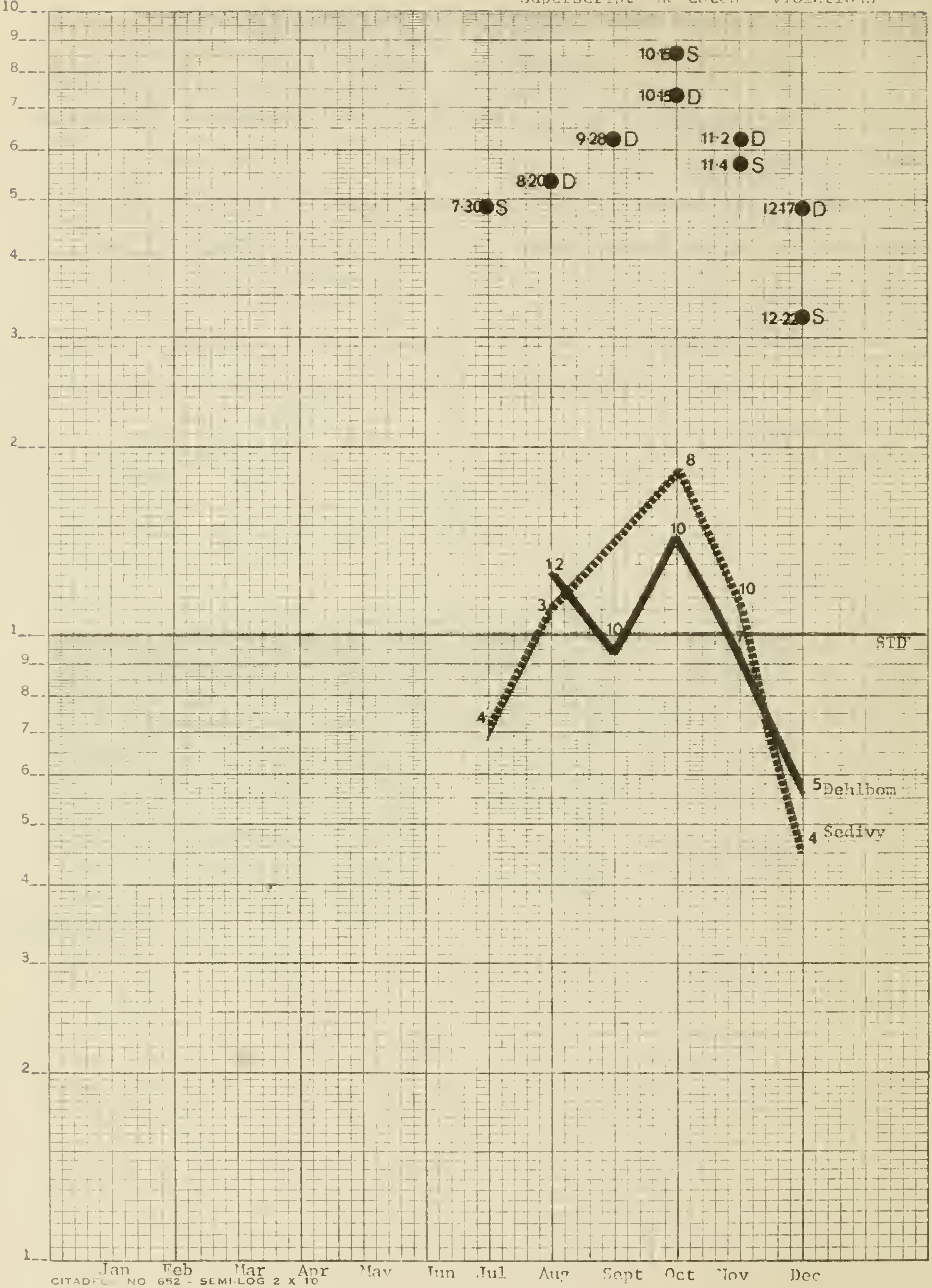
The dots in the upper portion of the graphs signify the maximum violations recorded in the month and the date of occurrence. The capitol letters are the initial of the site.

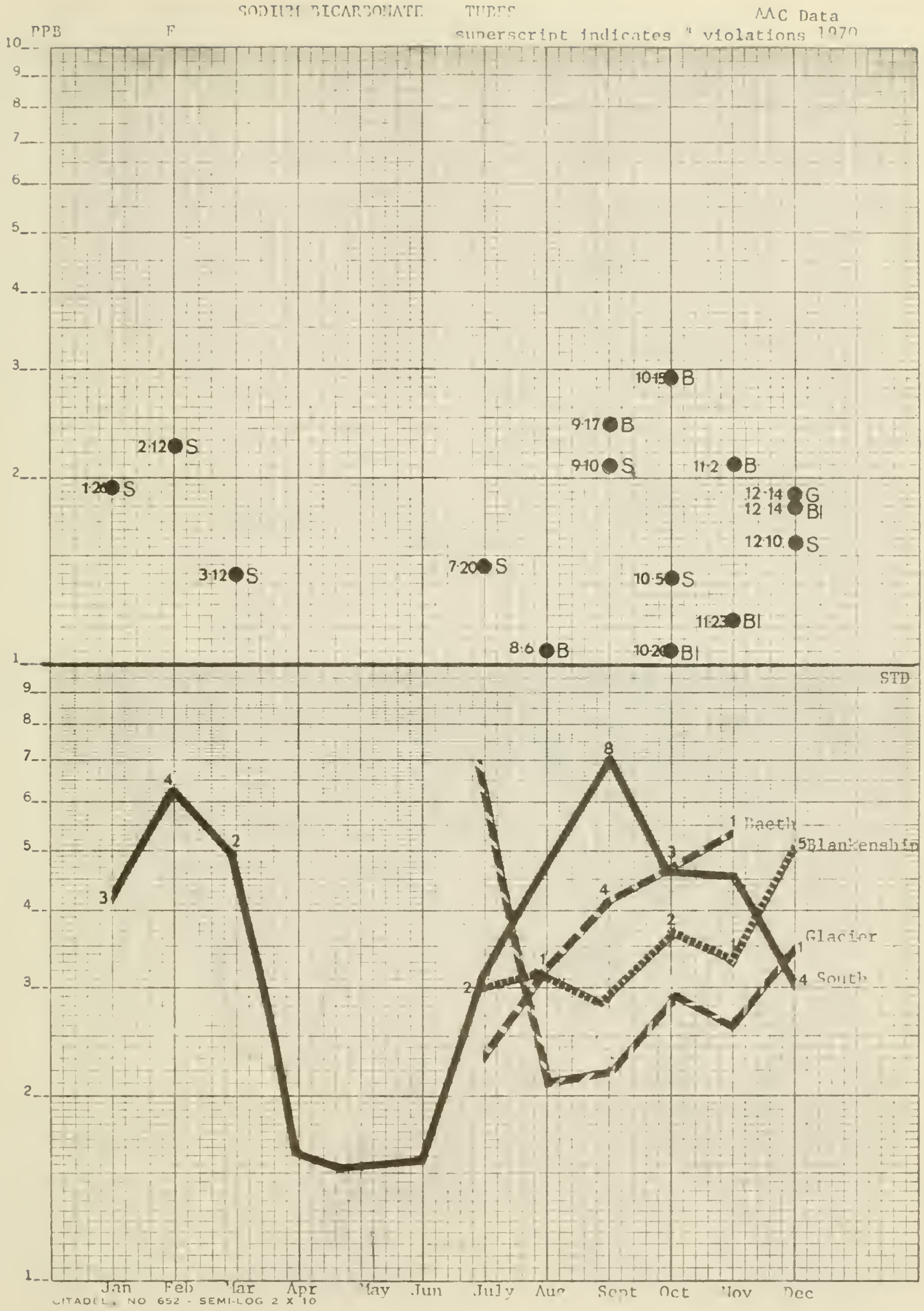


AAC Data

F SODIUM BICARBONATE TUBES 1970

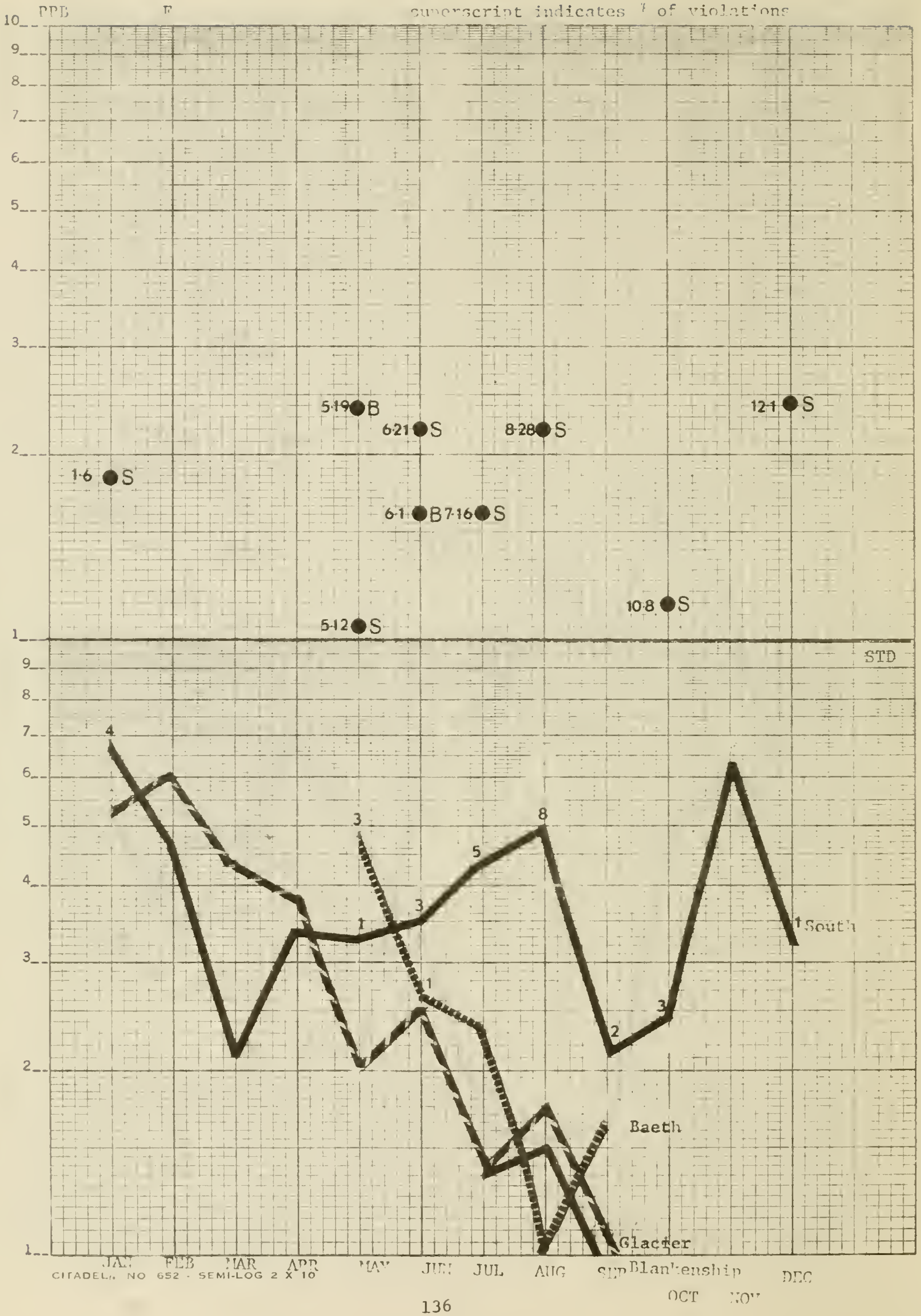
superscript indicates # violations



SODIUM BICARBONATE TUBES
AAC Data
superscript indicates # violations 1970
PPB
F
10
9
8
7
6
5
4
3
2
1
1·26 S
2·12 S
3·12 S
7·20 S
8·6 B
9·17 B
9·10 S
10·15 B
10·5 S
10·20 Bl
11·2 B
11·23 Bl
12·14 G
12·14 Bl
12·10 S
STD
9
8
7
6
5
4
3
2
1
3
4
2
2
1
8
4
3
2
1 Baeth
5 Blankenship
Glacier
1
4 South
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
CITADEL, NO 652 - SEMI-LOG 2 X 10

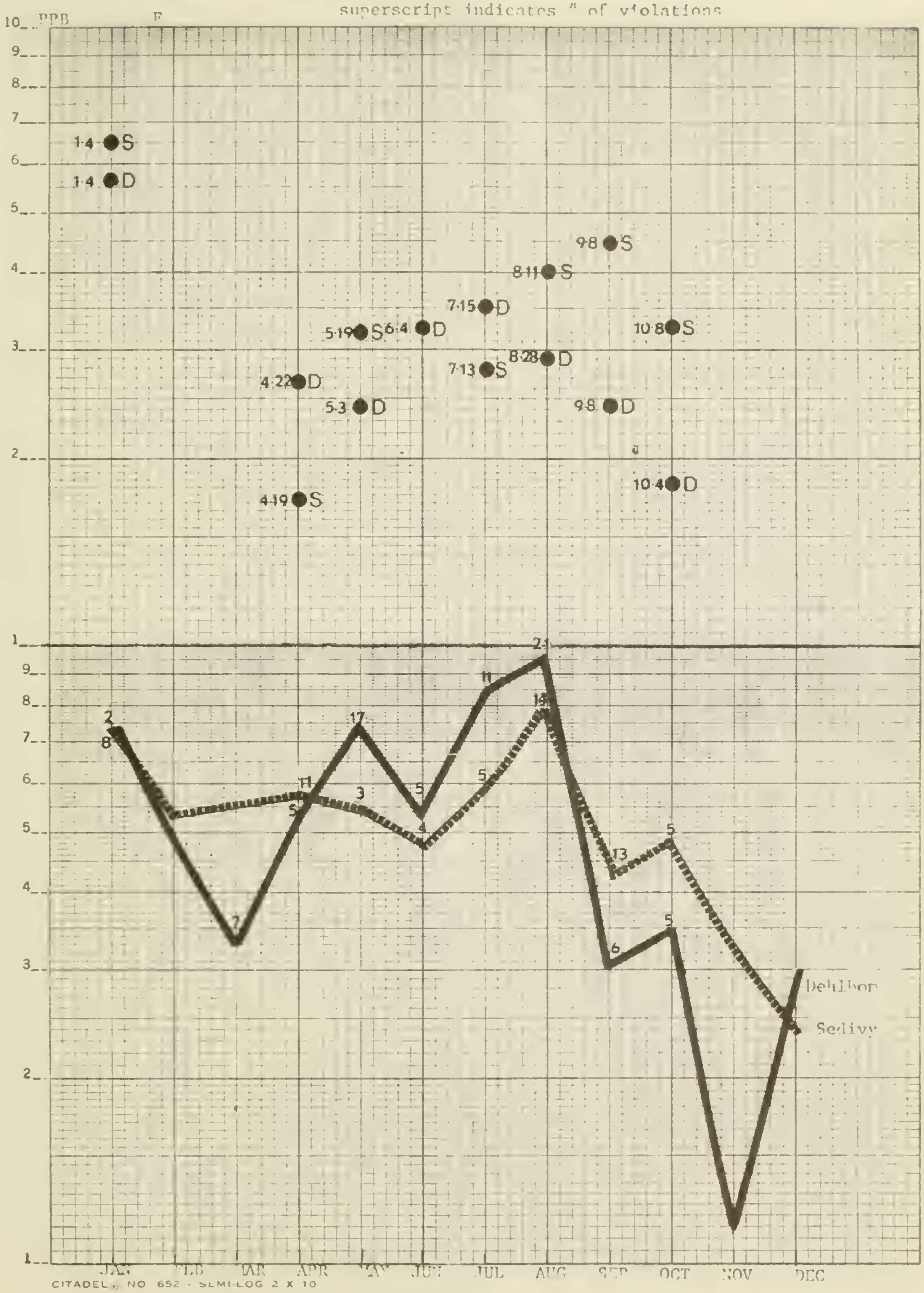
SODIUM BICARBONATE TUBES AAC Data 1971

PPB F superscript indicates # of violations



SODIUM BICARBONATE TUBES AAC Data 1971

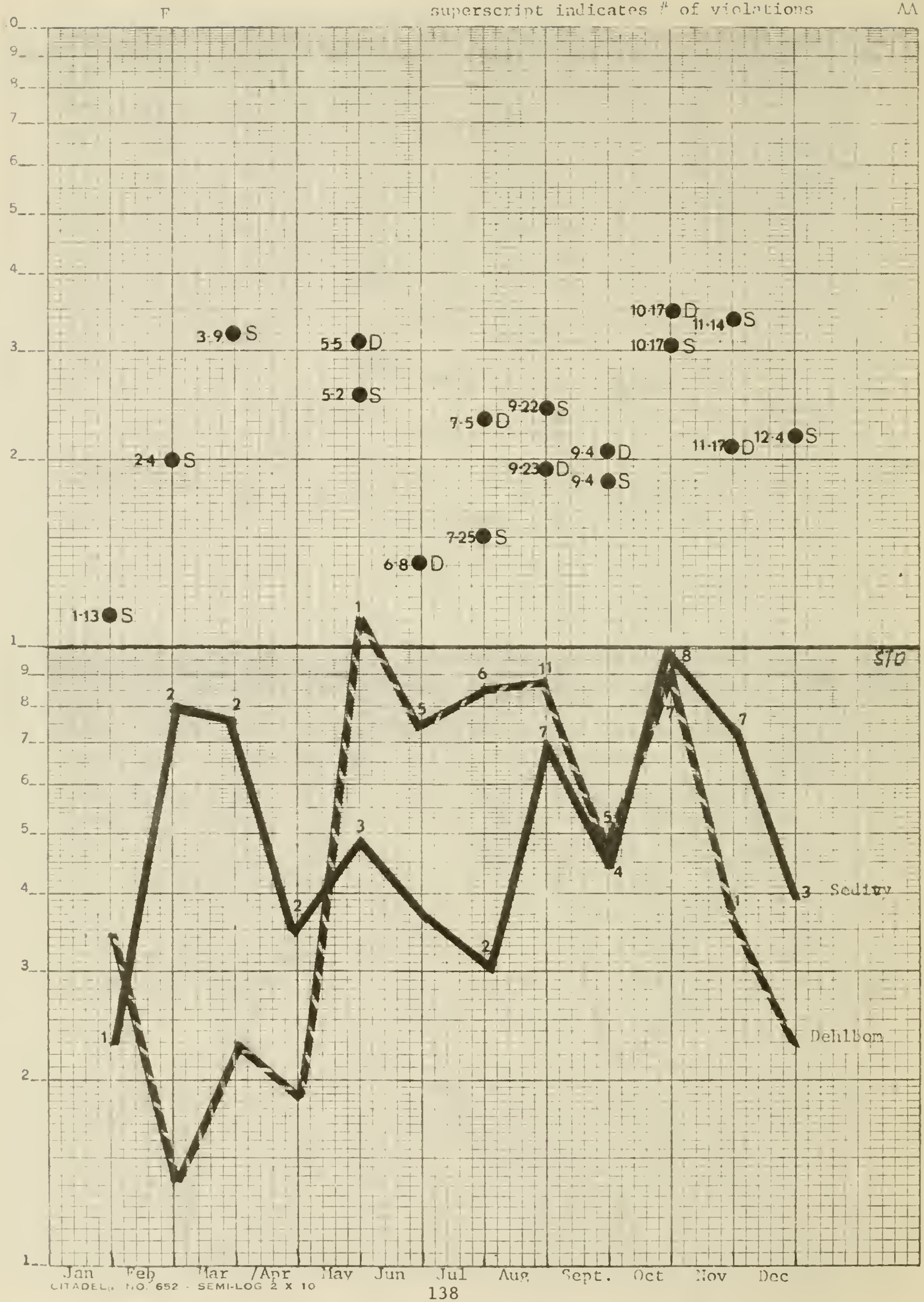
superscript indicates # of violations



SODIUM BICARBONATE TUBES 1972

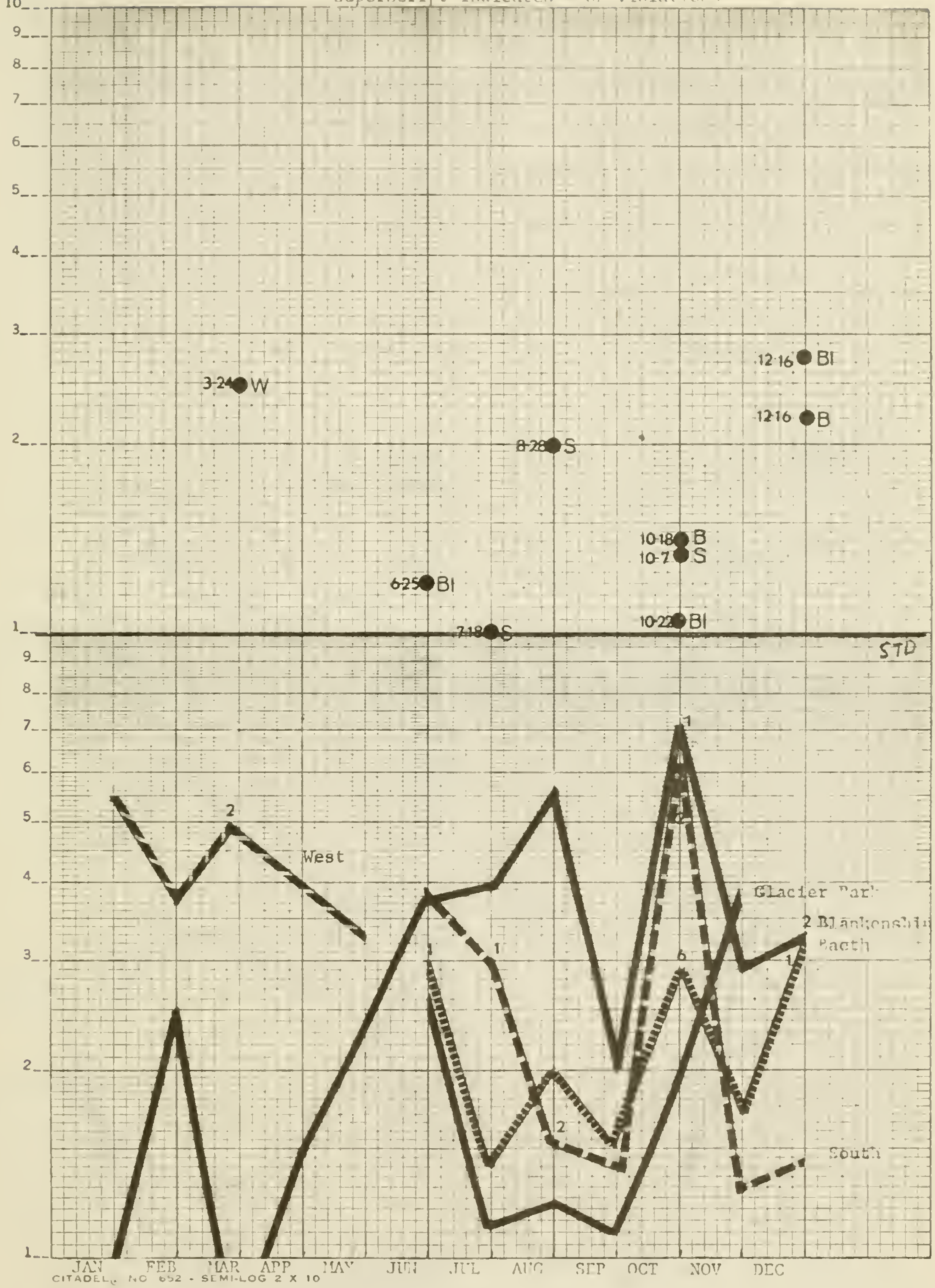
AAC Data

superscript indicates # of violations

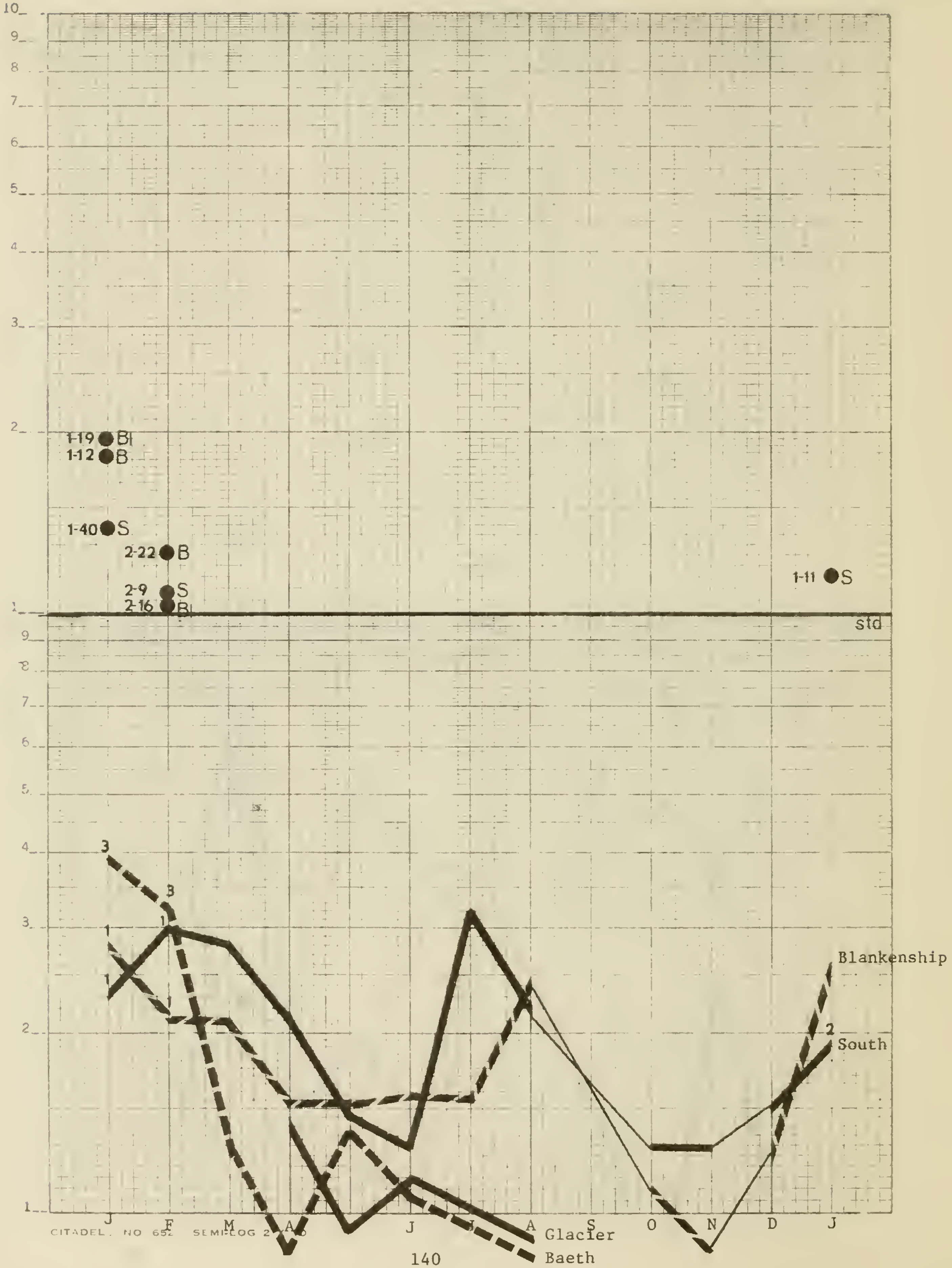


F SODIUM BICARBONATE TUBES AAC Data 1972

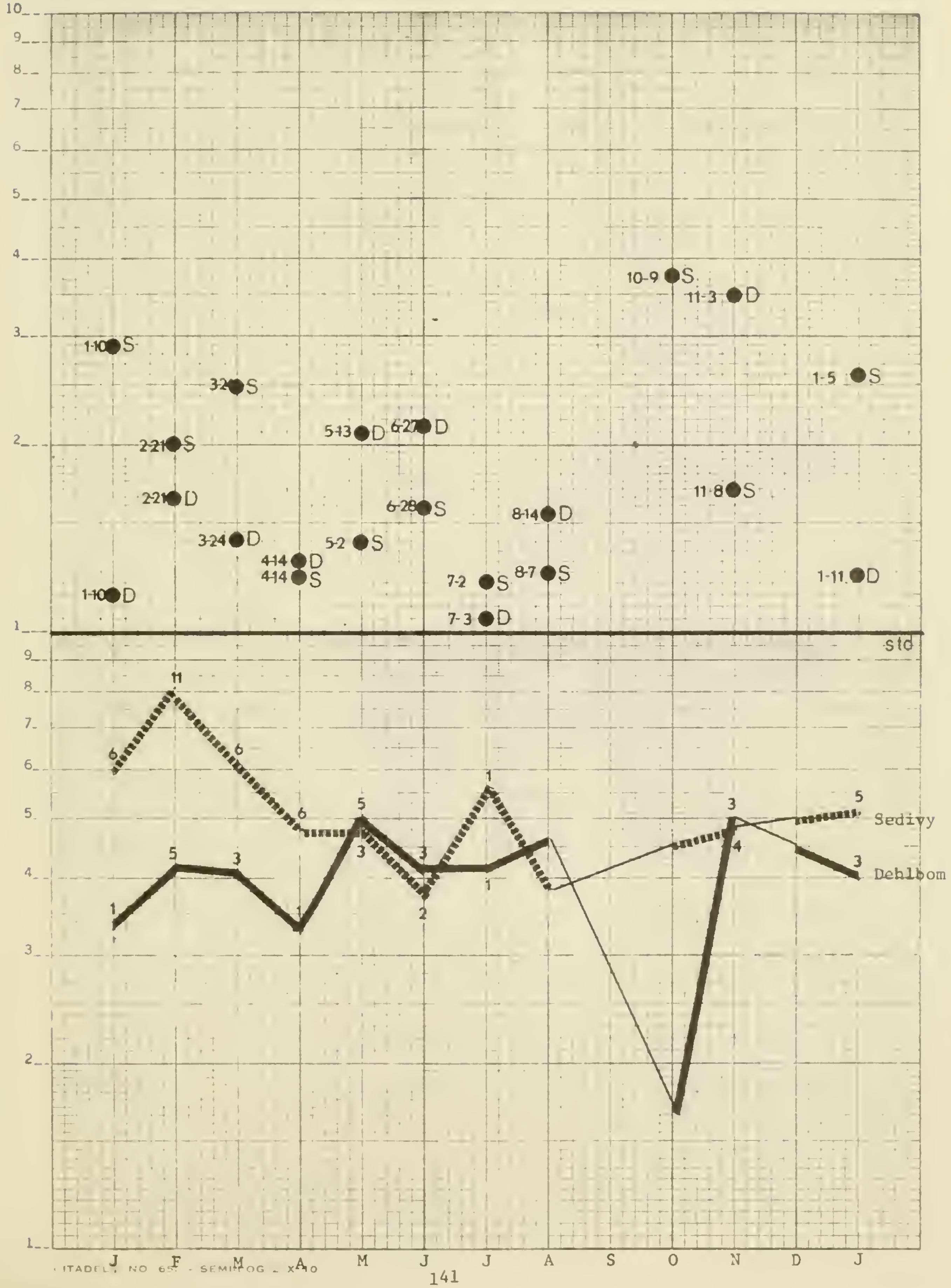
superscript indicates # of violations



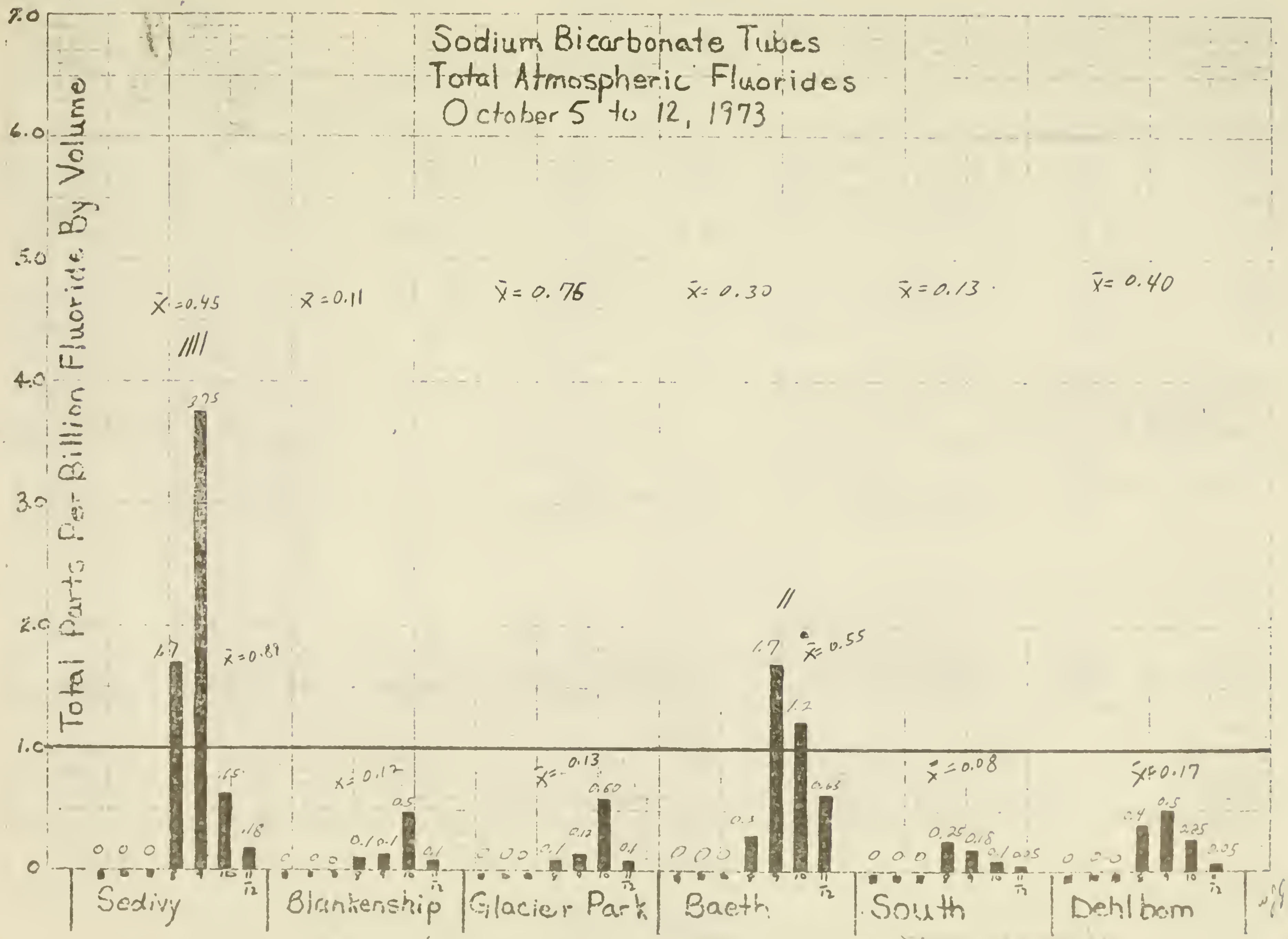
PPB F Sodium Bicarbonate Tubes AAC Data 1973-4



PPB F Sodium Bicarbonate Tubes AAC Data 1973-4



E.2 Selected Raw Data as Submitted by AAC



Sodium Bicarbonate Tubes
Total Atmospheric Fluorides
October 5 to 12, 1973

[illegible] SAMPLING

- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION		PERIOD	[illegible]	[illegible] m³ @ [illegible] COND	TOTAL, μgm. (F)		μGms (F) / m³		TOTAL μGms (F) / m³	TOTAL P P B by VOLUME (HF)
					Gas	Part	Ga	Part		
B-440F	Sedivy	10/8-9/73	24.0	15.49	11.8	8.7	0.76	0.56	1.32	1.70
B-441F		10/9-10/73	↓	15.50	24.8	20.3	1.60	1.31	2.91	3.75
B-442F		10/10-11/73		15.42	4.1	3.4	0.27	0.22	0.49	0.63
B-443F		10/11-12/73	19.7	12.41	1.5	0.2	0.12	0.02	0.14	0.18
B-444F	Blankenship	10/8-9/73	24.0	15.61	0.8	0.4	0.05	0.03	0.08	0.10
B-445F		10/9-10/73	↓	15.65	0.8	0.7	0.05	0.04	0.09	0.12
B-446F		10/10-11/73		15.56	3.0	3.0	0.19	0.19	0.38	0.49
B-447F		10/11-12/73	19.8	12.59	0.5	0.3	0.04	0.02	0.06	0.08
B-448F	Glacier Park	10/8-9/73	24.0	15.63	0.6	0.3	0.04	0.02	0.06	0.08
B-449F		10/9-10/73	↓	15.70	0.8	0.8	0.05	0.05	0.10	0.13
B-450F		10/10-11/73		15.73	3.2	4.3	0.20	0.27	0.47	0.60
B-451F		10/11-12/73	19.9	12.84	0.5	0.2	0.04	0.02	0.06	0.08
B-452F	Baeth	10/8-9/73	24.0	14.37	2.4	0.9	0.17	0.06	0.23	0.30
B-453F		10/9-10/73	↓	14.38	11.0	8.0	0.76	0.56	1.32	1.70
B-454F		10/10-11/73		14.33	5.9	7.8	0.41	0.54	0.95	1.22
B-455F		10/11-12/73	20.1	11.81	3.4	2.4	0.29	0.20	0.49	0.63
B-456F	SOUTH	10/8-9/73	24.0	15.46	1.6	1.4	0.10	0.09	0.19	0.24
B-457F		10/9-10/73	↓	15.47	0.3	1.4	0.05	0.09	0.14	0.18
B-458F		10/10-11/73		15.39	0.5	0.6	0.03	0.04	0.07	0.09
B-459F		10/11-12/73	20.2	12.75	0.3	0.1	0.02	0.01	0.03	0.04

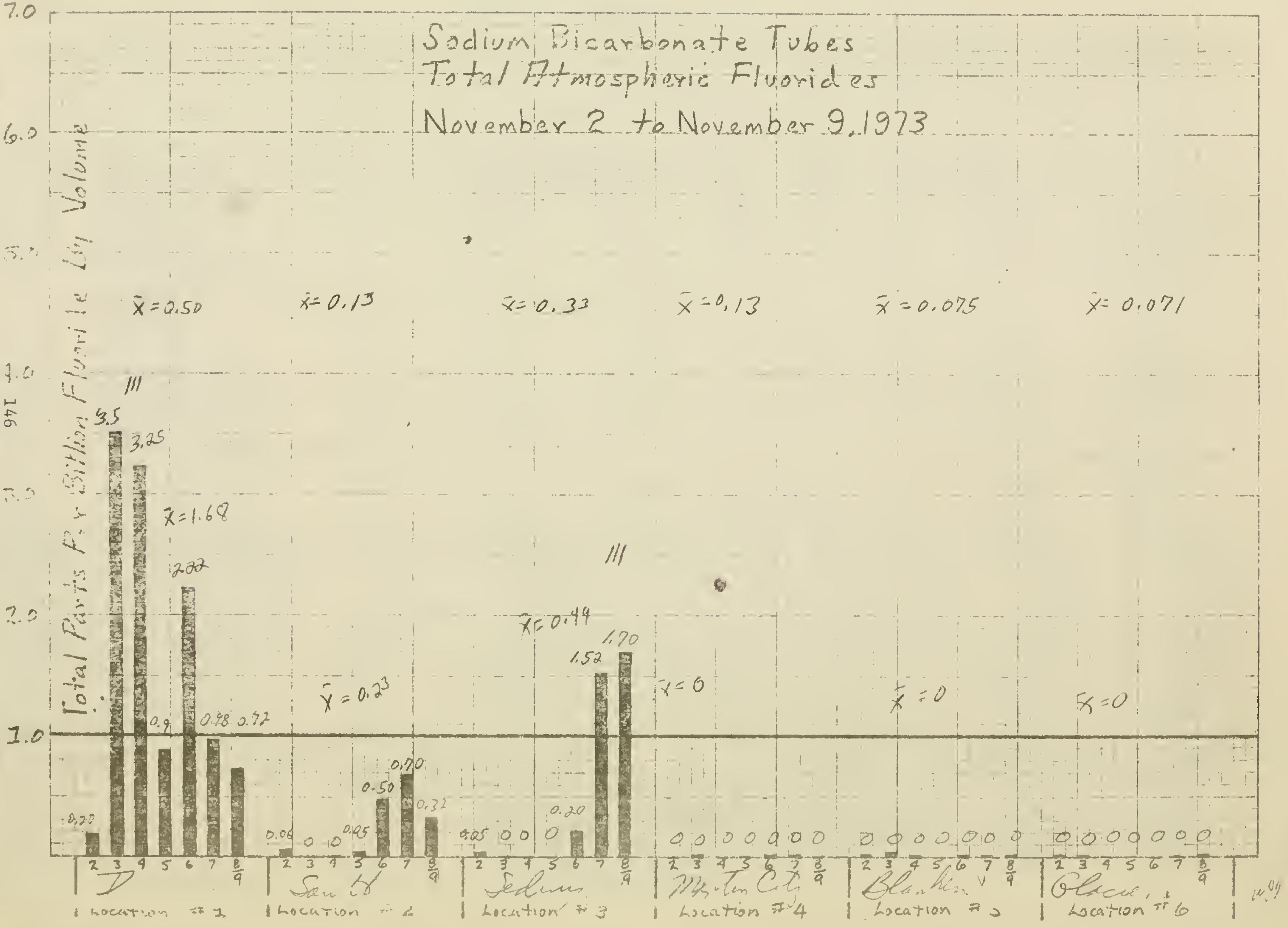
OIL BASE [illegible]

- (F) Con ntration -

SODIUM BICARBONATE

AMPLE NUMBER AND LOCATION	PERIOD	[illegible]	SAMPLE VOLUME m³ @ [illegible]	TOTAL μ m Gas	TOTAL μ m Part	μCms (F) / m³ Gas	μCms (F) / m³ Part	TOTAL μ Cms (F) / m³	TOTAL P ! B by VOLUME (HF)
B-460 F DEHLBOM	10/8-9/73	24.0	15.24	1.5	3.0	0.10	0.20	0.30	0.39
B-461 F	10/9-10/73	↓	15.28	2.7	3.3	0.18	0.22	0.40	0.51
B-462 F	10/10-11/73		15.25	0.9	2.2	0.06	0.14	0.20	0.26
B-463 F	10/11-12/73	20.3	12.68	0.4	0.2	0.03	0.02	0.05	0.06

K&E 10 X 10 TO THE INCH 46 0722
KEUFFEL & ESSER CO



Sodium Bicarbonate Tubes
Total Atmospheric Fluorides
November 2 to November 9, 1973

OIL PLANT SAMPLING

- (F) Concentration -

SODIUM BICARBONATE

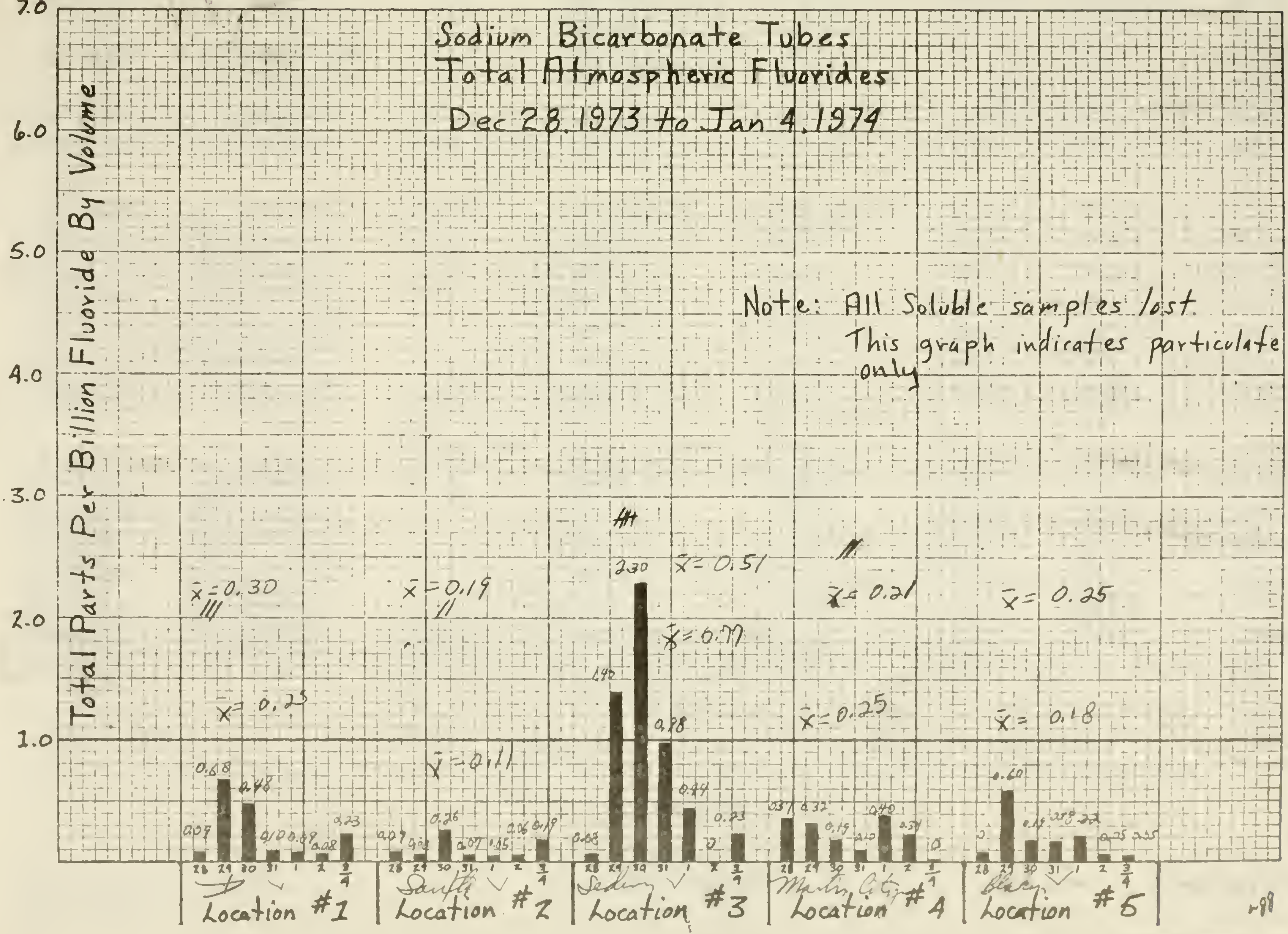
SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m³ @ STD COND	TOTAL µGms (F)		µGms (F) / m³		TOTAL µGms (F) / m³	TOTAL P P B by VOLUME (HF)
				Gas	Part	Gas	Part		
B-625 F	11/2-3/73	24.0	16.06	0.0	2.2	0.00	0.14	0.14	0.18
B-626 F	11/3-4/73		16.12	10.4	33.6	0.65	2.08	2.73	3.51
B-627 F	11/4-5/73		15.82	10.2	29.6	0.64	1.87	2.51	3.23
B-628 F Loc. #1	11/5-6/73		15.87	4.0	6.9	0.25	0.43	0.68	0.88
B-629 F	11/6-7/73		16.00	13.9	13.8	0.87	0.86	1.73	2.23
B-630 F	11/7-8/73		15.91	4.9	7.1	0.31	0.45	0.76	0.98
B-631 F	11/8-9/73		15.72	4.9	4.1	0.31	0.26	0.57	0.73
B-618 F	11/2-3/73	24.0	16.06	0.5	0.0	0.03	0.00	0.03	0.04
B-619 F	11/3-4/73		16.00	0.0	0.0	0.00	0.00	0.00	0.00
B-620 F	11/4-5/73		15.88	0.0	0.0	0.00	0.00	0.00	0.00
B-621 F Loc. #2	11/5-6/73		15.90	0.0	0.3	0.00	0.02	0.02	0.03
B-622 F	11/6-7/73		16.15	2.3	3.9	0.14	0.24	0.38	0.49
B-623 F	11/7-8/73		16.15	3.2	5.5	0.20	0.34	0.54	0.69
B-624F	11/8-9/73		15.72	2.5	1.5	0.16	0.10	0.26	0.33
B-590 F	11/2-3/73	24.0	16.12	0.3	0.0	0.02	0.00	0.02	0.03
B-591 F	11/3-4/73		16.24	0.0	0.0	0.00	0.00	0.00	0.00
B-592 F	11/4-5/73		16.25	0.0	0.0	0.00	0.00	0.00	0.00
B-593 F Loc. #3	11/5-6/73		16.27	0.0	0.0	0.00	0.00	0.00	0.00
B-594 F	11/6-7/73		16.24	1.0	1.7	0.06	0.10	0.16	0.21
B-595 F	11/7-8/73		15.91	5.9	12.9	0.37	0.81	1.18	1.52
B-596 F	11/8-9/73	23.6	15.50	11.0	9.5	0.71	0.61	1.32	1.70

OUT PLANT SAMPLING
- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m³ @ STD COND	TOTAL µGms (F)		µGms (F) / m³		TOTAL µGms (F) / m³	TOTAL P.P.B. by VOLUME (HF)
				Gas	Part	Gas	Part		
B-611F Loc. #4	11/2-3/73	24.0	14.88	0.0	0.0	0.00	0.00	0.00	0.00
B-612F	11/3-4/73	↓	14.86	0.2	0.0	0.01	0.00	0.01	0.01
B-613F	11/4-5/73	↓	14.66	0.0	0.0	0.00	0.00	0.00	0.00
B-614F	11/5-6/73	↓	14.63	0.0	0.0	0.00	0.00	0.00	0.00
B-615F	11/6-7/73	↓	14.83	0.1	0.0	0.01	0.00	0.01	0.01
B-616F	11/7-8/73	↓	14.69	0.1	0.0	0.01	0.00	0.01	0.01
B-617F	11/8-9/73	↓	14.55	0.0	0.0	0.00	0.00	0.00	0.00
B-597F Loc. #5	11/2-3/73	24.0	16.29	0.1	0.0	0.01	0.00	0.01	0.01
B-598F	11/3-4/73	↓	16.26	0.4	0.0	0.02	0.00	0.02	0.03
B-599F	11/4-5/73	↓	16.08	0.1	0.0	0.01	0.00	0.01	0.01
B-600F	11/5-6/73	↓	16.04	0.0	0.0	0.00	0.00	0.00	0.00
B-601F	11/6-7/73	↓	16.17	0.1	0.0	0.01	0.00	0.01	0.01
B-602F	11/7-8/73	↓	15.99	0.2	0.0	0.01	0.00	0.01	0.01
B-603F	11/8-9/73	23.9	15.79	0.1	0.0	0.01	0.00	0.01	0.01
B-604F Loc. #6	11/2-3/73	24.0	16.30	0.0	0.2	0.00	0.01	0.01	0.01
B-605F	11/3-4/73	↓	16.30	0.2	0.0	0.01	0.00	0.01	0.01
B-606F	11/4-5/73	↓	16.25	0.0	0.0	0.00	0.00	0.00	0.00
B-607F	11/5-6/73	↓	16.17	0.0	0.0	0.00	0.00	0.00	0.00
B-608F	11/6-7/73	↓	16.37	0.0	0.0	0.00	0.00	0.00	0.00
B-609F	11/7-8/73	↓	16.18	0.0	0.0	0.00	0.00	0.00	0.00
B-610F	11/8-9/73	23.9	15.88	0.2	0.0	0.01	0.00	0.01	0.01

K+E 10 X 10 TO THE INCH 46 0782
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



Sodium Bicarbonate Tubes
Total Atmospheric Fluorides
Dec 28. 1973 to Jan 4. 1974

Note: All Soluble samples lost.
This graph indicates particulate only

OUT PLANT SAMPLING

- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m³ @ STD COND.	TOTAL μ Gms (F)		μGms (F) / m³		TOTAL μ Gms (F) / m³	TOTAL P.P.B by VOLUME (HF)
				Gas	Part	Gas	Part		
B-926 F Location #1	12/28-29/73	24.0	15.64		0.9		0.06	0.06	0.08
B-927 F	12/29-30/73		15.76		8.2		0.52	0.52	0.67
B-928 F	12/30-31/73		15.88		5.8		0.37	0.37	0.48
B-929 F	12/31/73-1/1/74		16.24		1.2		0.07	0.07	0.09
B-930 F	1/1-2/74		16.21		0.9		0.06	0.06	0.08
B-931 F	1/2-3/74		16.40		0.8		0.05	0.05	0.06
B-932 F	1/3-4/74	21.8	14.82		2.5		0.17	0.17	0.22
B-932A F Location #2	12/28-29/73	24.0	15.87		0.9		0.06	0.06	0.08
B-933 F	12/29-30/73		15.97		0.6		0.04	0.04	0.05
B-934 F	12/30-31/73		16.18		3.2		0.20	0.20	0.26
B-935 F	12/31/73-1/1/74		16.39		0.7		0.04	0.04	0.05
B-936 F	1/1-2/74		16.37		0.5		0.03	0.03	0.04
B-937 F	1/2-3/74		16.62		0.7		0.04	0.04	0.05
B-938 F	1/3-4/74	22.4	15.28		2.3		0.15	0.15	0.19
B-939 F Location #3	12/28-29/73	24.0	15.81		0.8		0.05	0.05	0.06
B-940 F	12/29-30/73		15.88		17.3		1.09	1.09	1.40
B-941 F	12/30-31/73		16.12		28.7		1.78	1.78	2.29
B-942 F	12/31/73-1/1/74		16.30		12.6		0.77	0.77	0.99
B-943 F	1/1-2/74		16.34		5.5		0.34	0.34	0.44
B-944 F	1/2-3/74		16.55		0.0		0.00	0.00	0.00
B-945 F	1/3-4/74	22.3	15.22		2.7		0.18	0.18	0.23

OUT PLANT SAMPLING

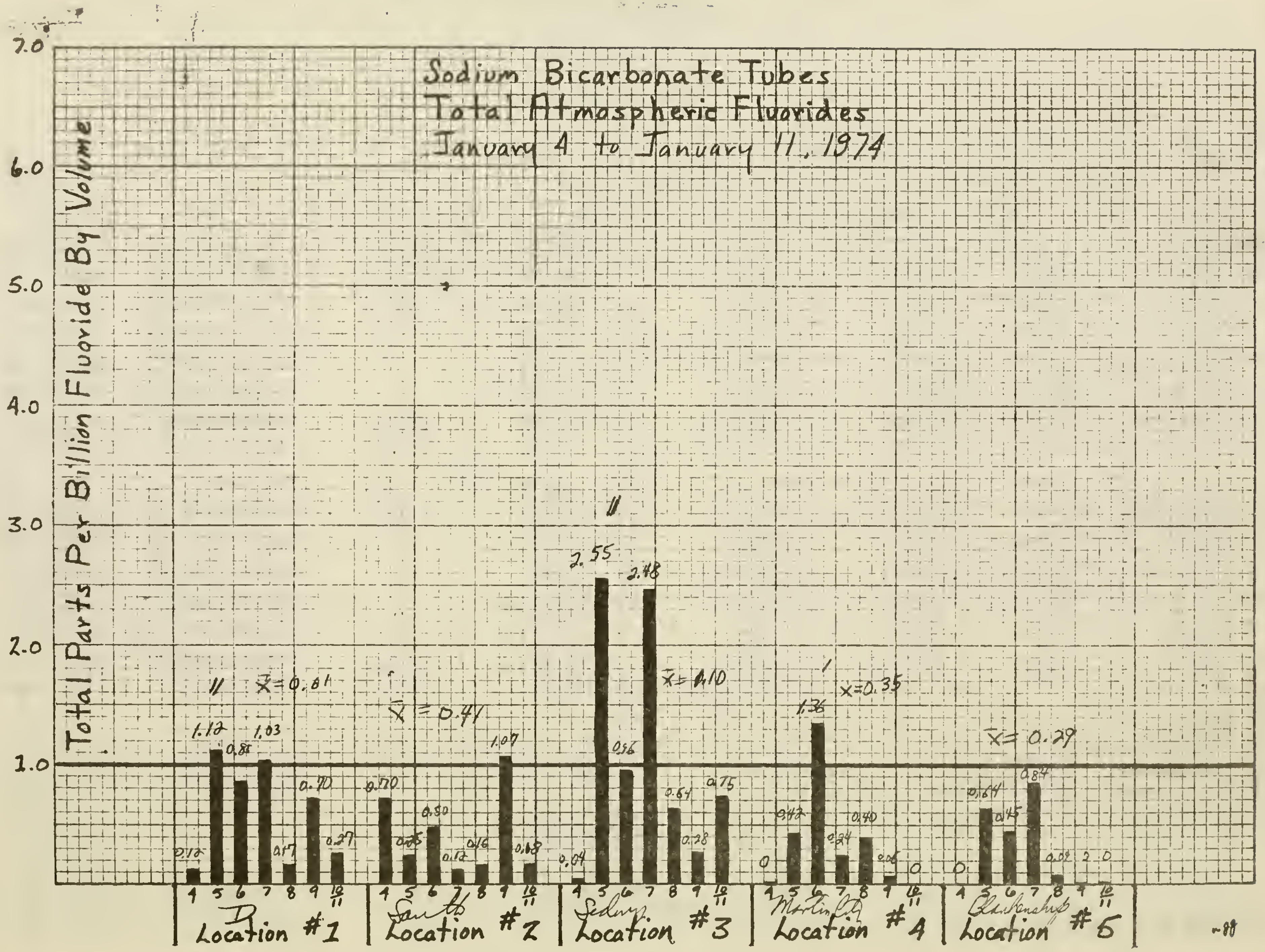
- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m³ @ STD COND	TOTAL µGms (F)		µGms (F) / m³		TOTAL µGms (F) / m³	TOTAL P P B. by VOLUME (HF)
				Gas	Part	Gas	Part		
B-946 F Location #4	12/28-29/73	24.0	14.69		4.3		0.29	0.29	0.37
B-947 F	12/29-30/73	↓	14.77		3.6		0.24	0.24	0.31
B-948 F	12/30-31/73		14.99		2.2		0.15	0.15	0.19
B-949 F	12/31/73-1/1/74		15.16		1.2		0.08	0.08	0.10
B-950 F	1/1-2/74		15.14		4.6		0.30	0.30	0.39
B-951 F	1/2-3/74		15.48		2.7		0.17	0.17	0.22
B-952 F	1/3-4/74	22.9	14.43		0.2		0.01	0.01	0.01
B-953 F Location #5	12/28-29/73	24.0	16.05		0.9		0.06	0.06	0.08
B-954 F	12/29-30/73	↓	16.11		7.4		0.46	0.46	0.59
B-955 F	12/30-31/73		16.45		2.3		0.14	0.14	0.18
B-956 F	12/31/73-1/1/74		16.41		2.2		0.13	0.13	0.17
B-957 F	1/1-2/74		16.54		2.6		0.16	0.16	0.21
B-958 F	1/2-3/74		16.64		0.6		0.04	0.04	0.05
B-959 F	1/3-4/74	22.3	15.47		0.5		0.03	0.03	0.04

Note: All Soluble samples lost

K+E 10 X 10 TO THE INCH 46 0732
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.


Sodium Bicarbonate Tubes
Total Atmospheric Fluorides
January 4 to January 11, 1974

OUT PLANT SAMPLING

- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m^3 @ STD COND	TOTAL μGms (F)		μGms (F) / m^3		TOTAL μGms (F) / m^3	TOTAL P.P.B. by VOLUME (HF)
				Gas	Part	Gas	Part		
B-960 F Location #1	1/4-5/74	24.0	16.46	0.7	1.0	0.04	0.06	0.10	0.13
B-961 F	1/5-6/74	↓	16.31	3.6	10.6	0.22	0.65	0.87	1.12
B-962 F	1/6-7/74		16.18	4.2	6.6	0.26	0.41	0.67	0.86
B-963 F	1/7-8/74		16.23	0.9	12.0	0.06	0.74	0.80	1.03
B-964 F	1/8-9/74		16.06	0.7	1.4	0.04	0.09	0.13	0.17
B-965 F	1/9-10/74		16.12	2.7	6.2	0.17	0.38	0.55	0.71
B-966 F	1/10-11/74	23.4	16.00	Lost	3.4	Lost	0.21	0.21	0.27 Part. only
B-967 F Location #2	1/4-5/74	24.0	16.30	4.8	4.3	0.29	0.26	0.55	0.71
B-968 F	1/5-6/74	↓	16.27	0.7	2.4	0.04	0.15	0.19	0.24
B-969 F	1/6-7/74		16.06	1.5	4.7	0.09	0.29	0.38	0.49
B-970 F	1/7-8/74		16.14	0.5	1.0	0.03	0.06	0.09	0.12
B-971 F	1/8-9/74		15.97	0.6	1.4	0.04	0.09	0.13	0.17
B-972 F	1/9-10/74		16.00	4.6	8.6	0.29	0.54	0.83	1.07
B-973 F	1/10-11/74	23.3	15.95	Lost	2.3	Lost	0.14	0.14	0.18 Part. only
B-974 F Location #3	1/4-5/74	24.0	16.58	0.2	0.2	0.01	0.01	0.02	0.03
B-975 F	1/5-6/74	↓	16.37	8.7	23.9	0.53	1.46	1.99	2.56
B-976 F	1/6-7/74		16.18	3.5	8.6	0.22	0.53	0.75	0.97
B-977 F	1/7-8/74		16.32	9.5	21.9	0.58	1.34	1.92	2.47
B-978 F	1/8-9/74		16.18	7.3	0.7	0.45	0.04	0.49	0.63
B-979 F	1/9-10/74		16.15	1.0	2.4	0.06	0.15	0.21	0.27
B-980 F	1/10-11/74	23.8	16.48	7.6	1.6	0.46	0.10	0.56	0.72

OUT PLANT SAMPLING

- (F) Concentration -

SODIUM BICARBONATE

SAMPLE NUMBER AND LOCATION	PERIOD	SAMPLE TIME	SAMPLE VOLUME m³ @ STD COND.	TOTAL μGms (F) Gas	TOTAL μGms (F) Part	μGms (F) / m³ Gas	μGms (F) / m³ Part	TOTAL μGms (F) / m³	TOTAL P.P.B. by VOLUME (HF)
B-981 F	1/4-5/74	24.0	15.33	0.1	0.0	0.01	0.00	0.01	0.01
B-982 F Location #4	1/5-6/74	↓	15.11	1.5	3.4	0.10	0.23	0.33	0.42
B-983 F	1/6-7/74		15.02	4.3	11.2	0.29	0.75	1.04	1.34
B-984 F	1/7-8/74		15.07	0.8	2.1	0.05	0.14	0.19	0.24
B-985 F	1/8-9/74		14.88	1.6	3.0	0.11	0.20	0.31	0.40
B-986 F	1/9-10/74		14.88	0.5	0.3	0.03	0.02	0.05	0.06
B-987 F	1/10-11/74	23.3	14.84	0.0	0.0	0.00	0.00	0.00	0.00
B-988 F	1/4-5/74	24.0	16.85	0.0	0.0	0.00	0.00	0.00	0.00
B-989 F Location #5	1/5-6/74	↓	16.54	0.2	7.9	0.01	0.48	0.49	0.63
B-990 F	1/6-7/74		16.39	0.6	4.9	0.04	0.30	0.34	0.44
B-991 F	1/7-8/74		16.47	1.2	9.6	0.07	0.58	0.65	0.84
B-992 F	1/8-9/74		16.26	0.4	0.7	0.02	0.04	0.06	0.08
B-993 F	1/9-10/74		16.29	0.2	0.0	0.01	0.00	0.01	0.01
B-994 F	1/10-11/74	23.8	16.48	0.1	0.0	0.01	0.00	0.01	0.01

STATE OF MONTANA/RECEIVED
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INTERGOVERNMENTAL RELATIONS
RESEARCH & INFORMATION SYSTEMS DIV.